metal **finishing** Journal

THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECH-
NOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION,
VITREOUS ENAMELLING, GALVANIZING, ANODIZING,
METAL SPRAYING & ALL METAL FINISHING PROCESSES.
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ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

Contents

U.S. AND US.

*I*N spite of the significant reduction in the output of motor-cars and other effects of the operation of the credit squeeze, the electroplating industry appears to be finding as much business as ever and is still working to the full extent of nickel availability. In fact it has been estimated (although the absence of any well attested figures for the industry must necessarily render any estimate liable to question) that in the past twelve months the output of plated articles in this country has increased by some ten per cent. There has also been considerable evidence of capital expansion in the industry with a marked trend towards the installation of automatic and semi-automatic plant.

This expansion of production and capitalization, which has taken place at a time when the rate of increase in many other industries has shown a marked deceleration, has served to keep the supplying industry adequately occupied in recent months. Moreover, it would appear that there is considerable faith in the continued prosperity of the electroplating industry to judge by the steady growth of new organizations and the supply of new processes in this country.

One of the notable features concerning the extension in the number of plating and finishing processes which are being made available in this country is that the overwhelming proportion of them are of overseas origin. Month after month the news has been coming in of the agency rights for process after process and plant after plant being taken up for marketing in this country. There is no doubt that the greater number of these processes are intrinsically excellent and worthy of use for the various purposes for which they are intended, but it is surely a matter of some regret that the industry should be so dependent on processes of other than U.K. origin. The situation very obviously stems from the difference in the amount of research and development work being applied to the evolution of metal finishing-processes as between this country and, in particular, Germany and the United States. Anyone who has been able to visit the large supply houses in the U.S.A. will have been impressed by the very great amount of money and effort devoted to the development of new plating processes, and the success of the application of such effort is reflected in the vast number and wide range of patents which have been taken out by American companies covering almost the whole electroplating scene. This is clearly evidenced in the field of bright nickel plating alone by the text and bibliographical references in the series of articles by Bellobono currently appearing in this Journal.

It is, of course, unrealistic to attempt to draw any direct comparison between British and American practice in view of the vastly greater resources available in the U.S.A., and there is in the U.K. no possibility of investing a comparable sum of money in electroplating research. Nevertheless, the electroplating industry in Great Britain is not exactly poverty-stricken in either money or brain-power, and other industries have shown clearly that they are quite capable of holding their own with all comers in the field of technical research and development.

It is therefore a fair question to ask the plating industry whether they are satisfied to continue using processes which have been developed elsewhere and whether they consider that an adequate allotment of their present prosperity is made towards rectifying the balance in the future.

Talking Points by "PLATELAYER"

COLOUR QUESTION

A MATTER which must now be causing makers of domestic equipment some concern is the increasing demand for colour in the kitchen. At the present time, makers of refrigerators, kitchen units and so on, seem to be concentrating on a limited number of simple colours; each one, however, acts on his own so that the consumer may well find that a particular item is available only in a colour which clashes badly with everything else in his kitchen. Most of the manufacturers still cover themselves, for the time being at any rate, by adding white to their standard range, so that one can still settle for this if the other available colours are too obtrusive.

A neat answer to the question has been found by at least one American manufacturer who has made kitchen furniture in white with inset panels in a contrasting colour. These are available in a wide variety of colours and enable the owner of the kitchen to change to a new colour scheme simply by clipping in a new set of panels.

IT TAKES ALL KINDS

THE Duke of Bedford recently got himself into hot water with the dustmen's trade union by saying to a gathering of public schoolboys that if they did not study they would end up as dustmen. Every so often someone tries to assess the relative importance of different occupations to the community, and there have even been attempts to argue that certain jobs are more responsible than others in totally unrelated fields and therefore should be better paid. Nothing could be more futile or unrewarding than this type of discussion, since in the last analysis, pay is determined by supply and demand; when good dustmen or managing directors are scarce one has to pay more to get them—or to keep them.

It does not seem to me that the Duke said anything outrageous—since it is fair to assume that the boys at the school would not have been sent there at great expense if it were intended that they should become dustmen, since this occupation, although a vital one, nevertheless does not require a long drawn-out and specialized training. Perhaps in other circumstances he might have issued a solemn warning against the dangers facing those who *do* become study addicts; they are liable to end up as lawyers, doctors or technicians, tied to an office desk or a fume-laden laboratory for an indeterminate number of hours and subject to the diseases of stress like thrombosis, ulcers, and nervous breakdowns. The alternative of an open-air life, with good pay, plenty of jobs to choose from, regular hours and limited responsibilities may well sound very attractive. Truly, as Ecclesiastes said: "In an abundance of learning there is much sorrow."

SIGHT AND SOUND

THE inconvenience and inefficiency of practically every lecture room in this country is being borne upon us now that the season of technical meetings is here. Actually, very few people complain about the prevailing conditions, because as there are almost no really up-to-date facilities in existence hardly anyone appreciates that there is anything wrong or that anything can be done about it. We accept as inevitable the fact that when the room is darkened to show slides, the lecturer becomes a disembodied voice speaking from the darkness; whilst if a light is provided on the rostrum he looks ghoulish. If he speaks while looking at the screen he has his back to the audience, and if he turns to the screen he cannot see his notes. If he wants to write on a blackboard he must put the lights on so that the image can no longer be seen, while in most cases the illumination will be so bad that his chalkings will be illegible also. This is quite apart from the acoustics and the fact that the ventilation is usually so poor that one emerges with a headache.

Yet there are many things that can be done with lecture rooms. Adjustable overhead spotlights that can be dimmed may be used to illuminate the lecturer's face and provide a focal point without dazzling him. Fluorescent lamps on the rostrum will adequately light notes, while blackboards can be lit in the ordinary way, or by means of a black lamp which will make fluorescent chalk writing visible in the dark in brilliant colours. With normal room lighting switched on, fluorescent chalks are also much brighter than the ordinary kind and are well worth using. Overhead projectors are now available also which enable the lecturer to project illustrations himself from the rostrum while facing the audience, but these are all too rarely seen. Other details are light controls which can be operated by the lecturer, a clock which he can see, a good signal system for slide changing, and an adjustable dais which will ensure that a small lecturer does not disappear from sight altogether!

Last, but not least, the lecture room should be well ventilated even when darkened.

In most cases the absence of these elementary facilities is not due to lack of money (they are not so expensive) but to lack of thought and imagination.

BRIGHT NICKEL PLATING
•   •   •

Chemical and Chemico-Physical Properties of Bright Nickel-Plating Baths

by Dr. I. R. BELLOBONO

DIRECT application of bright nickel coatings by adding to the bath so-called "brightening" substances has been utilized in recent years to an ever-increasing extent. Such substances can be divided into two basic classes, *viz.*, organic and inorganic brighteners.

The working conditions under which it is possible to obtain a good bright nickel coating by adding metallic salts can be maintained only with extreme difficulty in industrial plating plants. Consequently, modern baths operate mainly with organic additions.

On the basis of the experiments effected by Raub and Wittum[1], two groups of brightening materials must be distinguished, *viz.*, those having a strong action and those with a weak action (in a certain sense, a secondary action). These two groups are not only quite different from each other but, in addition, have different uses.

Influence of Brighteners and Anti-pitting Agents

The strong-action substances provide coatings of bright nickel, the reflectivity of which is equal to or little less than that of polished nickel, characteristics of their efficiency being:

(1) The brightness is independent of the thickness of the nickel coating. A good bright nickel bath must be efficient at high current densities and temperatures and must not be sensitive to variations of pH[2].

(2) There is an identifiable inclusion of alien substances in the nickel coating and it is inevitable that these become incorporated. The occluded hydrogen[3] found in electrodeposited nickel is attributed to the absorption of organic substances derived from the electrolyte during the course of deposition. Various analyses of carbon, hydrogen and oxygen have been made in different deposits and a certain hydrogen content is found even when there is no carbon (organic substances), it being possible for this content to amount to about 2 per cent. (by volume). This last-mentioned hydrogen is presumably of inorganic origin and is attributed to low cathode efficiency. There is no content of oxygen, however, in the absence of carbon. This confirms that all the occluded oxygen originates by absorption from organic substances containing it. According to W. L. Pinner, G. Soderberg and E. Baker[4], the amounts of carbon can vary between 0·05 and 0·2 per cent.[5] and those of sulphur between 0·02 and 0·06 per cent.[6].

(3) A large increase of polarization during the deposition of the nickel.

(4) Increase of hardness and decrease of ductility in the nickel.

(5) The frequent appearance of stresses in the interior of the nickel deposits, this depending to some extent on the thickness of the nickel coating.

The weak-action brighteners increase the reflectivity of the nickel less than the strong-action brighteners and, on the whole, the weak-action brighteners only provide deposits with a very weak or even milky lustre. They have the following properties:

(1) Marked reduction of brightness as the thickness of the deposit is increased.

(2) The identification of simultaneous depositions of alien substances is only possible in certain particular cases.

(3) Polarization during deposition of the nickel remains unchanged, even increasing a little.

(4) Slight increase in hardness and slight decrease in ductility.

(5) Reduced sensitivity of the nickel-plating baths to larger additions of brightening materials.

Of the aliphatic organic compounds, those belonging to the group of strong brighteners are: formaldehyde, acetaldehyde (to a lesser extent), thiourea and some albuminoid substances. Among the weak brighteners are long- or relatively long-chain alcohols and aldehydes, poly-valent alcohols (glycerine, carbohydrates) and substances containing the amine group as well as the ketone group.

In the case of the aromatic compounds, separation into the two classes is less marked. It is always possible, however, to formulate some general considerations. Among the strong brighteners are naphthalene, and its substitution products the naphthols, which give the nickel plate brittleness and bad adhesion. The amine group in the aromatic

compounds tend to diminish brightness and the sulphur of the thio- compounds (methylene blue, thio-diphenylamine) confers a brightening action on the mixture but worsens the other physical properties of the nickel.

No success has attended attempts to classify brighteners into strictly chemical categories which at the same time reflect their properties, they have, however, served to enable the peculiarities of the different groups to be more clearly distinguished.

Without immediately discussing the various theories propounded on the reactions of brighteners, the addition to bright nickel-plating baths of particular substances which serve to impede or prevent porosity and graininess which depend, in the main, on two causes will be considered. The causes are:

(a) A low cathode efficiency which leads to some degree of evolution of hydrogen at the cathode. This remains occluded through the small surface imperfections of the metal base, according to the observations of U. R. Evans and S. C. Shone[7];

(b) Absorption of brighteners or of organic impurities, excess of brighteners enabling them to act as organic contaminants[8].

In general, porosity increases as the thickness of the metal increases. There exists a critical thickness below which the deposits are practically unpitted. Overvoltage also exercises its effect and baths with high hydrogen overvoltages show little occlusion of hydrogen. After the first additions of oxidants (hydrogen peroxide, persulphates, perborates) recourse is had nowadays, for the prevention of this pitting, to wetting agents which lessen the surface tension of liquids as much as, to quote an example, 35 dynes per cm. in the case of water (almost half the normal value) when use is made of alkyl ethers (the best of which is the monododecyl ether of glycerine monosulphate) in quantities of 0·05 to 0·5 gm. per l.[9], or esters of sulpho-mono-carboxylic acids, or compounds of the class of the dodecyllic mono-ester of the sulpho-acetate of di-ethylene-glycol[10]. In addition, the sodium salts of tri-butyl or sulphonated tri-aryl aconitate[11] (0·01 to 0·2 gm. per l.) or thio-naphthene compounds and the like[12] (0·04 to 0·2 gm. per l.) have a quite beneficial action. This applies likewise to compounds of the type of sodium lauryl sulphonate. It should be borne in mind that excess of anti-pitter can cause dendritic phenomena, and the deposits to be brittle, cracked, swollen up or powdery.

Levelling Power

An interesting phenomenon is the ability of brighteners to ensure bright deposits of nickel even on metallic surfaces not previously in a state of perfect polish. Thus, rough surfaces having a metal base can become progressively brighter[13] as the thickness increases. It is thus possible to distinguish in such cases two different properties in bright nickel-plating agents, first, their levelling power (macroscopic action) and, second (microscopic action), their ability to give real brightness. According to Gardam[14], cadmium and zinc (in low concentrations, because in high concentrations they prove harmful) act at most only macroscopically, while normal organic brighteners usually have a microscopic action. Not all nickel-plating baths have levelling properties, and it may be noted, furthermore, that the actions of levelling and brightening are not related, in the sense demonstrated by Willson and Du Rose[15]. A pronounced levelling effect can be operated by semi-bright baths in a manner rather more satisfactory than the levelling effect obtained by baths producing greater brightness.

The importance of a bath's levelling power is seen at its true value when it is realized that surface defects on the metal base have for long been one of the main difficulties of the plating industry and that finishing costs are by no means insignificant. The advent of new and improved methods of examining and measuring imperfections in metallic surfaces, such as the profilometer, has made possible a systematic study of the defects and, hence, of the most suitable means of obviating or minimizing them. Among these, mention should be made of the Perflow process which has been put into operation by Harshaw. The Perflow process, although it does not provide a strictly bright nickel surface, guarantees levelling even when the deposit is quite thin.

Internal Stresses

Another interesting phenomenon in electrodeposits in general, and in nickel deposits in particular, is that of internal stresses. The first observations were made by Mills[16] in 1877 who described the results of experiments made in the electrolytic deposition of various metals on the silvered outer surface of a thermometer bulb. He observed that with some of these, for example nickel, iron, copper and silver, the mercury repeatedly rose slightly as the metal was being deposited, while with other metals (zinc and cadmium) the mercury in the capillary dropped. This was due to contraction or expansion of the bulb and for this reason Mills used the term "electrostriction" to describe these phenomena. The internal stresses are of considerable importance in quite a number of electroplating applications. In electroforming, excessive internal stresses in the deposit can cause swelling-out and detachment of the panel during the actual deposition, or slight contraction, causing reproduction to be inaccurate.

The values of the stresses can attain 40,000 lb. per sq. in. in Watts baths and rise to 54,000

lb. per sq. in. in baths with ammonium salts. Various methods have been devised for avoiding these phenomena, one being the application round the cathode of a magnetic field at right-angles to the direction taken by the ions to reach the cathode itself[17].

In deposits of bright nickel, some of which tend to be brittle, a high tensile force can induce internal microscopic porosity with, accordingly, increased risk of corrosion and exfoliation of the deposits is a fairly familiar manifestation of the internal shrinkage stresses. A potentially serious effect is the reduction in the fatigue strength of certain steels which have been machined and coated with deposits of nickel or chromium. These sometimes amount to as much as 60 per cent. of the fatigue strength before deposition and are attributable in the first place to internal forces caused in these deposits by the chromium or by the nickel, thus giving rise to a serious limitation in the use of such deposits, especially in the aircraft industry in which, otherwise, they could have been of enormous use.

Many of the methods used for detecting internal stresses are based on measurement of the curvature suffered by a thin metal plate on one side of which a metal is deposited[18], but in the case of nickel under ordinary operating conditions, variations in temperature or of current density have only a small effect on stresses, although at temperatures below 30° C and at very low current densities these variations perceptibly increase. Brenner and Senderoff[19] have studied the effects of bath composition and pH in baths of the Watts type or of double nickel-ammonium salts and the presence of impurities in commercial solutions increases the shrinkage stress to 32,000 lb. per sq. in. Increasing the pH to the maximum limits, this value increases to 33,000 lb. per sq. in. Conversely, the value drops if the pH is lowered to the extreme limit of the scale of acidity, as was shown by Hothersall[20]. The addition of peroxides (1 gm. per l. H_2O_2) causes an intense increase of stress in pure Watts baths having a pH of 4·2 (up to 42,000 lb. per sq. in.) and, accordingly, the same applies to the addition of some surface-active agents and organic brighteners, which have also the power of deflecting the direction of the forces. Saccharine drastically reduces these forces to 2,700 to 4,500 lb. per sq. in. and, consequently, so does sodium naphthalene trisulphonate, the effect of which has already been reported by Hothersall and Gardam[21]. Chlorine ions, finally, have a tendency to increase the internal stresses.

No satisfactory explanation of these internal stresses has so far been evolved, but it is very probable that there is no single cause but a simultaneous exercise of several causes which may be mutually helpful or obstructive. The theories appearing in the literature suggest that metal ions become discharged and form metal atoms or systems of atoms, which become deposited, together with non-metallic substances, in a metastable form. A very rapid establishment (perhaps instantaneous) of equilibrium is then effected, accompanied by a change in volume, and, if the initial deposit is adherent to the metal base, this circumstance can induce internal stresses (tensile or compressive according to the conditions prevailing) in the deposit

Much of the experimental evidence implies that the high internal stress in nickel deposits is due to the hydrogen which is deposited at the same time. Hothersall, in fact, demonstrated, using specially pure nickel salts, that when the internal stresses increased the pH dropped between three and two in accordance with the concomitant increase in the discharge potential.

As soon, however, as internal stresses are observed in metals in which the cathodic efficiency is in the vicinity of 100 per cent. (like lead, copper or silver), other causes become evident in addition to the absorption of hydrogen. Soderburg and Graham[23] ascribed responsibility for these phenomena to metal surface tensions, while other authors ascribe them to the hardness and microstructure encountered from Weisberg cobalt baths, which reveal high stresses. In addition, other factors contribute to a very considerable extent in circumscribing and defining this use and the applications to which it may be put. Other investigators ascribe them to the crystal form and effects of the metal base, which are related to the levelling power of the bath. Marie and Thon[24] have shown that possible cavities between the surface of the metal base and the surface of the superimposed deposit also tend to promote elastic stresses. Also, the effect of the organic agents is very specific in this field and by means of them it is possible, according to their nature, either to increase or diminish the internal stresses, as has been indicated.

Although knowledge of the origin of these internal stresses is still incomplete, it is possible to moderate them to the extent required, sometimes sacrificing other of the deposit's properties (for example, *brightness*, if it is necessary completely to *avoid* any coating stresses) or at least diminishing the degree desirable. Research pursued in this field would not only clarify this problem but also lead to a more complete understanding of the mechanisms involved in electrodeposition in general and to all that this implies.

Effects of Supersonics

Among the important effects that can be caused by purely physical phenomena, is that of the production of bright nickel deposits by Roll[24] by means of ultrasonic waves (34 kilocycles). He observed that bright deposits were obtained only with a higher current density when the intensity

of the ultrasonic waves was increased. While in the original bath, bright nickel was obtained at 2·7 ma. per sq. cm., when there was an emission of ultrasonics at 0·3 W. per sq. cm., it was possible to get a bright deposit (only) with 40 ma. per sq. cm. This fact has been explained by the theory that the component of additional motion of the ions resulted in a movement inclined towards the cathode surface. If the angle was smaller than that required for brightening, the deposit became granular; if larger, the deposit was inhomogeneous but bright.

The effect of ultra-violet light from a mercury arc lamp on nickel baths was studied by Duval and Liger[25], who obtained the same effect as that which would have been found if the pH of the bath had been raised.

Effect of Current Density

Industrial bright nickel-plating baths usually operate at 4 to 5 amp. per sq. dm. and at 40 to 50° C. A discussion of the limiting current density, *i.e.*, that above which "burned" deposits are often obtained, involves many factors. It is necessary to take into consideration the concentration of metallic ions, the temperature, agitation in relation to the cathode and to the solution, the pH and chloride concentration of the bath. All these factors are mutually related in such a way that if one variable is altered without a corresponding modification of the current density, bad effects are soon noted on the cathode deposit.

High current densities can be used if the content of metal ions or chlorine ions is raised or if the temperature is raised. The permissible range of current density can be widened by lowering the pH, as Phillips[26] has clearly shown. In the same article he has discussed the interrelationship of pH, current density and temperature, taking note of a major effect on current density caused by variations of temperature at low pH values. The movement of the cathode which permits of effective and constant renewal of the solution in its vicinity allows the use of higher current densities.

Effect of pH

There are two distinct modifications of typical Watts baths in respect of the current range in which they are operated, *viz.*, the baths with low pH (1·5 to 3·0) and those with high pH (4·5 to 5·6). Phillips and others demonstrated the advantages and disadvantages of low pH as follows:

(1) Low pH permits the use of a wider range of current density.
(2) It permits the use of higher current densities.
(3) Deposits of greater uniformity are obtained.
(4) Cotton[27] and others note a rapid and marked increase in the efficiency of the cathodic current with pH values below 2·3.

(5) Macnaughten and Hammond[28] established the fact that the hardness of electrodeposited nickel rapidly decreases with the rise in the pH from 2·0 to 4·5. Whether this change in hardness is or is not associated with absorption of hydrogen seems to be an open question. It should be observed, however, that a metallurgically "hard" nickel acquires a high degree of brightness more easily than a "soft" nickel.

In the bath with low pH, the lower part of the range (1·5 to 2) must be used with full awareness of its limited "throwing" power. This last, according to Haring[29] is favoured by a high concentration of nickel salts in the bath, by low acidity (high pH), by the presence of chlorine ions, by moderate buffering, by agitation of the solution adjacent to the parts of the cathode which receive the highest current density, this last factor allowing an increase in the nickel hydrogen ratio in the neighbourhood of the catholyte to be effected.

Throwing Power

According to C. Reinhard[30], low current density and absence of metallic impurities (such as copper and zinc) lead to fairly good results, so far as throwing power is concerned. Flowers and Warner[31] found that throwing power is greatly improved by an increase in the number of nickel ions at a pH preferably on the low side. Harr[32] discusses the effects of ferric ions, which he found reduce the throwing power from —28 per cent. to —103 per cent. Ferrous ions, however, have no particular disturbing effect and the addition of traces of them is contemplated in certain patents for semi-bright nickel[33]. Large additions of ferrous ions, however, according to Madsen[34], cause brittleness in the nickel deposited.

The throwing power, in addition to being a function of the relationship of the cathode potential to the current density and of the resistivity of the bath[35], is also a function of the distribution of primary current, a factor to be borne particularly in mind, especially in the case of more involuted shapes, as Pinner[36] emphasizes.

According to the definition of Haring and Blum[37], "throwing power" is understood to mean that property of the solution by virtue of which a relatively uniform distribution of metal on a cathode of irregular shape is obtained. If a cathode of rather complicated shape is immersed in an electrolytic bath and two small areas of its surface are considered, one of which is nearer the anode than the other, the respective current densities, if no polarization phenomena occur, are inversely proportional to the distances of the areas from the anode. This condition can be produced, approximately, by using h.f. alternating current. The ratio of this hypothetical current density (known

as "ratio of primary current") depends entirely on the arrangement of the anode and of the cathode and on their dimensions and is independent of the composition of the electrolyte. Direct current, however, produces polarization at the cathode, which increases with the current density. This has the effect of reducing the said density in that part of the cathode which is more polarized and, consequently, the "ratio of secondary (or "actual") current" approximates more closely to unity than that of the primary current.

The throwing power of a solution is the difference of the ratio of metallic distribution, which, in its turn, is proportional to the ratio of secondary current to primary current and is generally expressed as a percentage of the ratio of distribution of the primary current.

Hence, if the primary current ratio is K : 1 (K exceeding 1) and M : 1 is the corresponding ratio of metallic distribution, the throwing power emerges as:—

$$\frac{(K-M)\ 100}{K}\ \text{per cent.}$$

It is evident, therefore, that a negative throwing power is a possibility and would signify that, on the part of the cathode farther away from the anode, more metal has been deposited than would have been expected from the ratio of the primary current.

The factors governing the throwing power of a solution are:—

(a) The slope of the deposition-potential/current-density curve among the values of

Fig. 1.—The Hull cell.
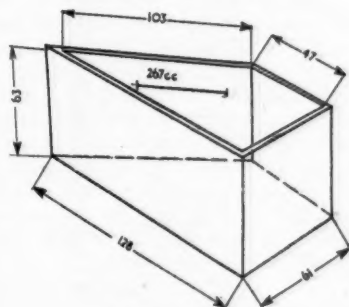
current density on the parts near to and far from the cathode: This represents the excess of polarization of the near portion over that of the far portion and is, in general, the principal factor enabling good throwing power to be established.

(b) Conductivity of the electrolytic bath: If the conductivity is high, the potential drop through the solution with a given current density will be relatively small and, hence will not succeed in making any great change in the difference of polarization on the two typical areas, one near to and one far from the anode, considered above. If the conductivity, however, is low, the potential drop will be large and hence will reduce greatly the good effect of the differential polarization.

(c) Efficiency of the cathodic current: This varies with the current density and thus modifies the effect of polarization. This factor can be either a help or a hindrance in producing a good throwing power.

Control and Manipulation of the Baths

It is essential that the pH of bright plating baths is controlled as a variation of a few tenths of a unit can cause considerable differences in brightness in given deposits of bright nickel. Maintenance of the pH is an easy matter with buffering agents, of which the principal in this field is boric acid. In ordinary bright nickel-plating baths the pH tends to increase; it can usually be lowered by adding a small amount of H_2SO_4 or HCl according to which anion is preferred.

It is not appropriate in this survey to discuss the methods of measurement of these chemical, electro-chemical or physical and mechanical variables of the baths and of the deposits of bright nickel, e.g., pH, concentration of metal, surface tension, throwing power, hardness, brittleness of the coatings, their ductility, porosity, etc. Fuller information on these is given in reference [39]. However, some consideration must be given to the main objective of these baths viz., a constant value of purity and concentration.

The existence of such an ideal situation would imply that until such a solution were exhausted, all the electrodeposited coatings would be of equal thickness, would be endowed with equal properties when being treated or subsequently manipulated during fabrication and would have equal "wearability" and corrosion resistance in service. Commercial practice inevitably falls short of this Utopian standard, either because some impurities can be introduced in harmful quantities, or because the composition of the essential elements of the solution varies. These causes result in the need for corrective measures (purification and filtration)
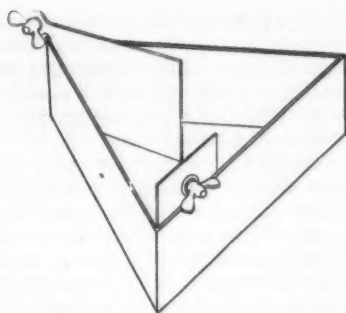
Fig. 2.—The "triangular" cell

and for strict analytical checks on the additions. to the solutions.

In addition, it is necessary to check the current density applied to the electrodes and see that it does not vary outside indicated or specified limits. The taking of these measurements and the making of these determinations can be effected experimentally in a reasonably practical way by means of Moehler's "fissure" cell[40], or of Hull's[41] even better-known cell (Fig. 1), both of which have the peculiarity of producing a cathode deposit with a current density varying from one end of a single surface of a metal plate to the other. The use of the Hull cell for bright nickel plating has been studied by many firms and, in Italy, by E. Bertorelle and E. Costa[42], with particular reference to zinc and copper impurities which cause smoky black streaks and patches, to the organic materials which cause shiny streaks alternating with black, and to the nitrates which cause complete blackening of the plate. E. Bertorelle [43], furthermore, has developed the use of a "triangular" cell[44] (Fig. 2) for the study of nickel-plating electrolytes. By means of specimens contaminated with zinc, copper and iron, marked effects on deposits can be observed, from which it is possible to determine the type and obtain a semi-quantitative estimation of the metallic impurities present. This triangular cell has the pertinent advantage, when compared with the earlier cells of Hull and Moehler, of being able to make use of a wider range of current density in the same specimen with subsequent increased exploration capacity.

Fig. 3 shows the results of various tests performed with the Hull cell and by varying the conditions of a bright nickel bath[45]. These results clarify the effect of the contaminating agents on the deposits.

The solid impurities which are filtered out of the bath can be the result of accidental contaminations, like anode mud (hence the use of anode bags), or may be the result of particular chemical treatments for renewing the solution, or of purifying it of dissolved contaminants. The accidental con-

taminants mentioned, which can be eliminated easily by continuous or discontinuous direct filtration, can be, besides the anode mud already mentioned, particles of powder or of iron hydroxide or of basic salts, if the bath operates with a sufficiently high pH to allow of their precipitation. They could produce granular deposits by physical occlusions and a typical effect is that of the particles of ferric hydrate, studied in the nickel-plating baths of Thomas and Blum[46] and of Thompson and Thomas[47].

The contaminating substances which cannot be removed by direct filtration like those described

Fig. 3.—Schematic summary of the deposits from a Udylite bath on test strips in the Hull cell. Each strip was plated for 5 min. at 3 amp. at 45°C.
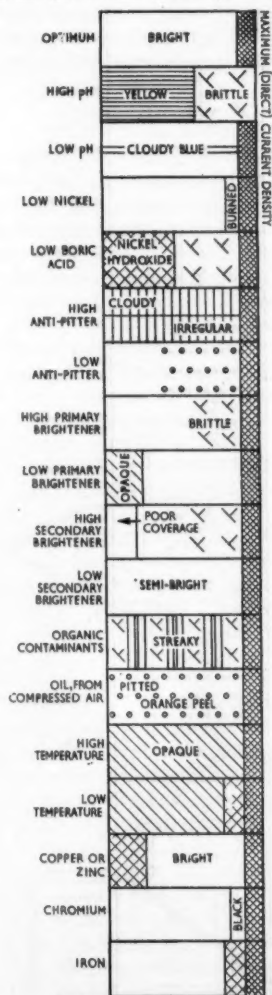
above and which are subjected to chemical treatments for regenerating the bath are the metallic impurities, such as ferrous iron, copper and zinc[48]. These last two considerably reduce throwing power, especially at low current densities. Even colloids, the actual brighteners themselves, and organic substances, in general, produce, when present in large quantities, deposits which are brittle, streaky or spongy, even if, sometimes, they succeed in preserving their brightness. In particular, the oily substances in the electrolytes, which contain surface-active agents, do not float on the surfaces but are dispersed in minute drops, resulting in the production of a nickel deposit containing many small pits, and thus having little or no corrosion resistance.

The metallic impurities are eliminated by preliminary electrolyzing at a low current density[50] or by chemically precipitating them by means of reactions which vary in each individual case[51]. The organic impurities, before being decomposed with oxidizing agents like hydrogen peroxide, potassium permanganate or chlorine, are absorbed on active carbon. The bath, thus renewed and, at the same time deprived of its brighteners and surface-active agents, is then ready to receive the additions suitable for making it once again effective in producing a bright deposit.

The following describes a method of purifying bright nickel baths of a typical Watts composition, containing special brighteners. The working conditions include a temperature of 45 to 60° C (it is important that it should, in general, not go below 40 to 45° C), a current density at the anode of between 1 and 4 amp. per sq. dm., one at the cathode of 2 to 8 amp. per sq. dm.; continuous filtration and movement of the cathodes. The impurities in these baths can be insoluble substances which can be eliminated by decantation (large amounts of sludge), by simple filtration, or by filtration through filters of cloth or of cardboard covered with a thin layer of asbestos flakes or of Kielslguhr or diatomaceous earth. Through this type of filter, however, semi-insoluble substances, e.g., colloids and very minute particles such as atmospheric dust or very finely divided anodic sludge can pass which only a filter of minimum porosity (like Gooch N.3. or even as low as N.4) would succeed in trapping.

Soluble substances, finally, can be eliminated either by electrolytic methods similar to those described above or by chemical procedures consisting mainly of treatments with 10 per cent. potassium permanganate or hydrogen peroxide followed by adsorption on active carbon.

The inorganic impurities are usually iron, copper or zinc compounds and only occasionally compounds of chromium or aluminium. The iron, when oxidized, precipitates at a pH of about 5; aluminium precipitates, however, at a pH of a little

above 5. Excessive raising of the pH has its disadvantages among which may often be a greater consumption of brightener. In eliminating copper and zinc, the preliminary electrolyzing is effected on corrugated cathodes with a view to avoiding any further formation of the blackish brown deposit which denotes the presence of zinc.

If chromium is present in the bath in the hexavalent form, it is rather difficult to separate out. In such a case it is reduced to the trivalent form with sodium bisulphite. Trivalent chromium precipitates as the hydroxide when the pH is raised to the vicinity of 5.

It is advisable, every two or three months, to pump all the solution into the reserve vat to see whether any material for plating may have dropped to the bottom, particularly copper or zinc, and to inspect the general cleanliness of the vats, of the anode bags, of the anodes themselves, which have to be frequently brushed, especially if they are not of the depolarized type. It is desirable to check the filtering properties of any bags which it has been found necessary to empty and wash.

All specific cases, however, have necessary variants and while it is possible to establish classifications and general rules along broad lines for bright nickel baths, every single object to be plated constitutes a specific problem which is always worthy of attentive and expert study with a view to obtaining the best result by making use of the best technical means available. It should be understood however that bright nickel plating is not a panacea for all the problems involving nickel-plating.

The main disadvantage of the process of bright nickel plating is, as Such [52] has previously observed, its association with a tendency to brittleness and to internal stresses due mainly to the organic agents which are inevitably incorporated in the coating. Another factor limiting its application to some extent is the difficulty of keeping an analytical check on the agents themselves, the rapid, simple and sufficiently accurate determination of which has hitherto not been a practical proposition. It is thus often preferred, as has already been mentioned, to use baths giving a semi-bright deposit, but in which the more favourable chemicophysical and physical properties of the nickel deposit are preserved.

An ideal bright nickel bath, Such continues, should be stable during a long period of operation, simple to analyse and should have constituents which are not very sensitive to organic and inorganic impurities. It should also, for preference, be easily purified and have a good throwing power. The deposit given should have satisfactory adhesion (this is damaged by preceding pickling treatments with excessively strong acids), have low internal

ABRASION RESISTANCE OF VITREOUS ENAMEL

Some Details of American Test Equipment

THE U.S. National Bureau of Standards has recently developed a simple and rapid device for determining the abrasion resistance of porcelain enamels. The instrument provides a reliable means for testing enamels having different types of finishes, including "orange peel" and wavy surfaces. While the abrasion tester was designed primarily for porcelain enamels, it can be used for determining the wear resistance of such other materials as highway paints, plastic and fibrous materials, and organic finishes. The instrument and test method was developed for the Institute by G. Warren and J. H. Giles, P.E.I. Research Associates at the Bureau.

Abrasion resistance is one of the most important factors in the service performance of protective coatings. Floor coverings are subjected to scuffing, and enamelled sinks and cooking utensils are

Fig. 1.—*Curves illustrating relationship between weight loss and abrasion time for three porcelain enamels and a glass plate tested in the abrasion tester. Numbers in parentheses are the slopes in mg. per min.*

Each curve is almost a straight line; for porcelain enamel this relationship holds until the enamel is penetrated and the underlying ground coat or base metal is exposed.
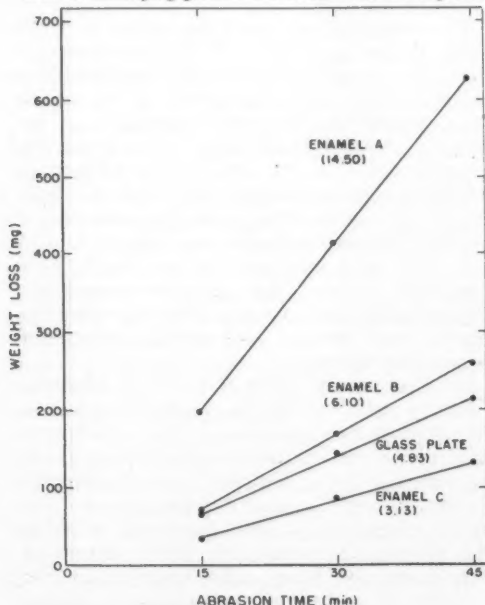
Fig. 2.—*P.E.I. abrasion tester developed recently at the U.S. National Bureau of Standards for determining the abrasion resistance of porcelain enamels and protective coatings.*

The instrument provides a rapid, reliable method for testing enamels having different types of finishes, including "orange peel" and wavy surfaces.

frequently scoured with cleansing powders containing fine abrasives. Since all enamels are not equally resistant to abrasion, techniques for predicting the service behaviour on the basis of laboratory measurements are of considerable value to porcelain-enamel manufacturers. The Bureau, in co-operation with the Porcelain Enamel Institute, has been working for a number of years on the development of suitable methods and instruments for testing surface coatings. The most recent result of this work is the P.E.I. abrasion tester.

The instrument consists essentially of a motor-driven table gyrating in a horizontal plane at 300 r.p.m. The table moves parallel to itself, and describes a circle $\frac{7}{8}$ in. in diameter. The table is driven by a $\frac{1}{4}$-h.p. synchronous motor, and the testing time is accurately controlled by an electric timer. Nine specimens, $4\frac{1}{4}$ in. sq., can be fastened to the table for simultaneous testing.

A specimen is placed in one of the nine available positions on the table and secured with a rubber-coated aluminium retaining ring. An abrasive charge consisting of 3 gm. of abrasive grit, 17·5gm.

A Comparative Survey of
STOVING
by
CONVECTION and RADIATION
by LEO WALTER, A.M.I.Mech.E., M.Inst.F.
(Concluded from page 298, August, 1956)

OPERATION OF DRYING STOVES IN METAL FINISHING

PREVIOUS articles in this series have sought to stress the fact that both convection and radiation stoving systems have their own particular value. One of the leading paint manufacturers in this country states, that if a user of their paints asks for their opinion they advise him according to the type of article which is being surface coated. This firm (and other paint manufacturers of repute) has in its laboratories several specimens of test stoves of both types available. These ovens are representative of stove types made by leading British stove manufacturers. The firm claims that they require these in order to evaluate the large demand for the many varying types of stoving enamels required by industry. This paint manufacturer also says that, "we cannot give an opinion 'off the cuff' as to which method of stoving is the most efficient or the most economic until one has fully investigated the whole circumstances concerning any particular industrial plant".

The above confirms on the part of paint manufacturers the greatly empirical character of the choice of stoving system to be made whenever a new finishing plant is contemplated. It also matches the picture given previously by stove manufacturing firms, who offer an opportunity for potential clients to carry out all tests with either type of equipment in order to substantiate claims made. Experience properly applied will prevent failure. In this final instalment a few more convection stoving installations will be described and illustrated, which have proved their value under actual operational circumstances.

Control of Forced-air Circulation Ovens

It has been mentioned before that the drying time in a convection conveyor stove is determined by the batch of articles going through which requires the longest time to dry. At the same time it must be made sure that if other batches are conveyed that they will not be overstoved. For articles of a more complicated size and shape there may be sections which need prolonged exposure to the hot air in order to dry, but there may also be sections on the article which dry much quicker.

It is in these cases that thermostatic control of the hot air is essential. Whatever form of temperature regulator is employed, and irrespective of the heating medium, *e.g.*, steam, hot water, gas, or electricity for warming the ingoing air, the temperature of the latter must be kept below the critical stoving temperature. This is determined by those batches which take the shortest time to dry during
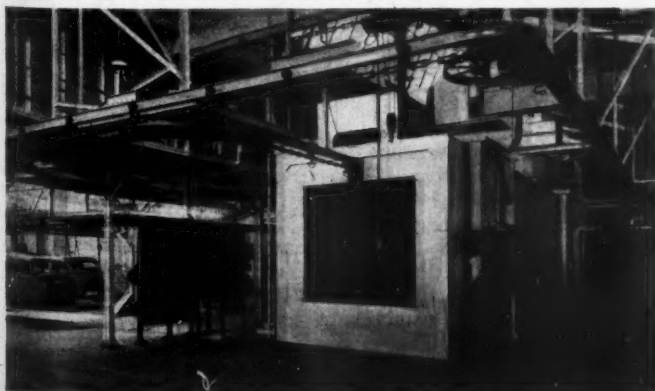
Fig. 1.—*"Perfectair" dry-off stove used after acid-rub, for handling passenger-car bodies. This is a convection oven using steam coils. (Courtesy Perfectair Ltd.).*

Fig. 2 (right) — Two "Perfectair" ovens for stoving sports-car bodies —air - circulated gas - fired type. (Courtesy Perfectair Ltd.).

Fig. 3 (left)—An Austin car type A.30 body emerging from one of the high-temperature ovens by way of a cooling tunnel. (Courtesy The Austin Motor Co., Ltd.).

Fig. 3a (right)—Layout of forced-convection conveyor-oven plant for automatic dipping.
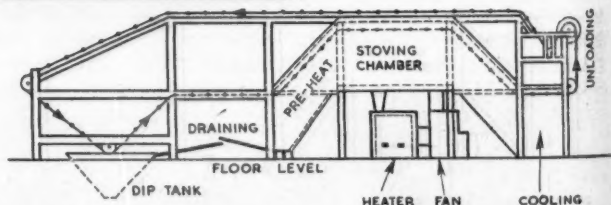
their passage, and for a single complicated article by the section which dries quickest. (Fig. 1.) On the other hand, the thermostat, or in the case of zoning, several temperature regulators, should be set so that the hot air coming into contact with the goods is not too far below the critical point, because otherwise unnecessary time would be lost. The obvious conclusion from this would be to use the oven for a single type of article, uniformly loaded at the rated capacity.

Although beneficial in theory, practice does not always allow operation under such optimum conditions. Modern rapid stoving methods reduce drying time and allow maximum permissible temperatures, but here timely withdrawal of the article is essential in order to avoid breakdown or discolouring of the coating. It depends very much on working conditions whether rapid convection stoving will be safe in practice, and this method certainly requires greater care than the old batch

Fig. 3b—Steam-heated and gas-fired ovens for motor-car bodies. (Courtesy Briggs Motor Bodies Ltd.).

stoving method, or the standard conveyor stoving method. Fig. 2 illustrates, as an example of a well-designed plant, two ovens for stoving sports-car bodies. Both stoves are of the air-circulated gas-fired type. The pneumatically operated doors can be seen raised at the exit ends.

Many users claim that the high-pressure steam-heated oven has several advantages over other oven types where certain kinds of organic finishes are used. Where located along a wall, several methods of loading can be carried out simultaneously. Ground-level tracks, hoist and overhead conveyor chain, or hand loading with racked articles can be applied. Where a steam-heated oven is located in the centre of the enamelling department, a single- or double-decker conveyor system serves equally well (Fig. 3).

The steadily increasing demands from modern mass-production methods are best met for smaller articles by the modern forced convection conveyor oven. Several variations in design can be found in practice, but the basic factor applied remains the same. Fig. 3a illustrates a modern plant designed for automatic dipping and drying. As has been mentioned before, one of the main reasons for elevation of the stoving chamber above the shop floor level is to achieve sealing of both ends of the oven, as the hot air rises to the top.

It should be mentioned that the hot air in a well-designed oven of this type is continuously kept in a highly turbulent condition. This produces rapid heat transfer between circulating air and the stoved article, and ensures uniform heat distribution throughout. From the paint manufacturers' point of view, the speed of drying is a secondary consideration. The first consideration is obviously that a system should be used which ensures the complete curing of the paint film without spoiling it.

As an example of a very large oven installation, Fig. 3b illustrates a plant at a works where over 1,000 car bodies are produced per day. Obviously, mass production of this kind has its problems, and stoving just has to fit in. The oven construction makes use of wall and roof panels of sheet metal. Glass wool insulation of 4-inches minimum thickness is used at a density of 3 pounds minimum. The assembled panels have a "K" value of less than 0·4 B.Th.U. per sq. ft. per ° F.

Each oven is equipped with an air seal. The ovens are heated by steam coils when used for final enamel stoving. Gas burners are used in priming ovens of this type.

Operation of
Forced-air Circulation Stoves

The factors to be supervised and controlled in conveyor ovens using forced air circulation can be briefly summarized as follows:

(a) Speed of goods through the stove.
(b) Hot-air temperature.
(c) Hot-air volume.
(d) Position of articles in relation to direction of air stream;
     and
(e) Purity of air.

Gas is widely used in convection ovens of moderate size and some people claim that it has considerable advantages. Gas as a heating medium is extremely controllable. Electric heating elements may continue to dissipate heat long after the power supply has been cut off and the dissipation of heat maintains and might even increase the temperature of air in circulation. This can sometimes, in practical stove operation, cause difficulty in thermostatic oven control.

Fig. 4a (right)—A standard gas-fired hand - dipping oven, with normal equipment suitable for sprayed or dipped work. (Courtesy F. J. Ballard and Co. Ltd.).
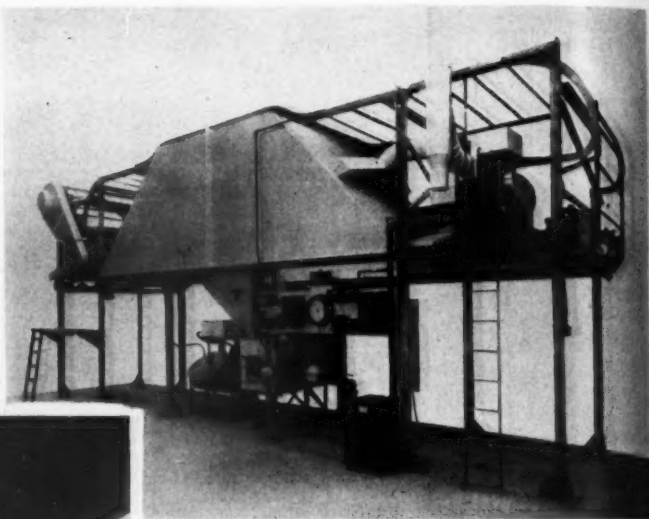
Fig. 4b (below)—Very small automatic gas-fired oven for high output. (Courtesy F. J. Ballard and Co. Ltd.).
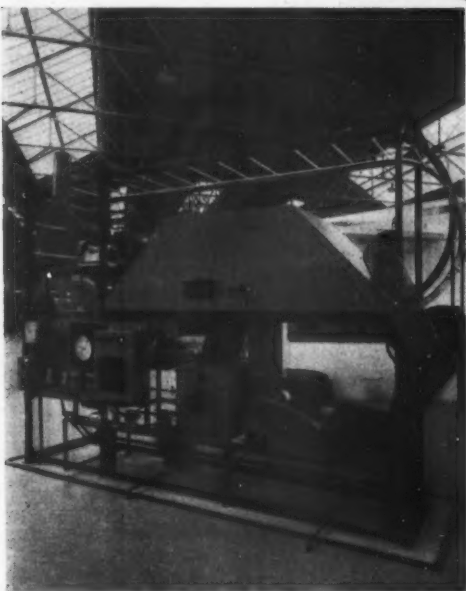
Operation of oil-fired ovens, of which at the present time there are only a few in use, can be nearly as convenient as with town's gas. Paint manufacturers dislike direct oil-firing, where the products of combustions are mixed with air and come into contact with the painted article surface. Where a very high-class of finish is not required, and where the right type of fuel oil is used in an efficient modern oil burner with controllable combustion, oil firing can have its merits and be economical.

Details of Some Interesting Plants

The forced-air circulation stove in its modern design lends itself to a multitude of uses, when designed with a view to operational efficiency, and with all consideration to local space conditions. A few examples should be of interest, because they demonstrate the versatility of this oven type. Fig. 4a illustrates a Ballard standard gas-fired hand-dipping oven, with normal equipment, suitable for sprayed or dipped work. A temperature recorder with circular chart supervises stoving temperature, and gas consumption is metered, as shown. Fan and conveyor operation is kept reasonably noiseless due to lubrication and use of efficient transmission elements.

In Fig. 4b is shown an extremely small, fully automatic gas-fired oven. It is capable of returning the work to the feed end, and is fully protected with a flame failure device. The designer produced a virtually semi-portable unit, having a relatively high production output for its dimensions. In contrast Fig. 4c illustrates an extremely large automatic dipping plant in operation. It uses two oil-fired ovens in tandem, preceded by a drying-off oven, used for drying the work after phosphating. This oven is approx. 26 ft. wide and about 300 ft. long, and is used in manufacture and painting of window frames.

Typical stoving times for the above ovens depend, of course, upon type and quantity of work, nature and application of finish, etc. Assuming that the finish is a stoving enamel, the number of coats required also being taken into consideration, times generally vary between 5 and 45 minutes and (with certain exceptions) temperatures vary between 300 and 450° F.

Among several installations in operation at the works of the Austin Motor Company Ltd., and supplied by Carrier Engineering Co. Ltd., of London, is the oven illustrated in Fig. 5. In this plant the initial treatment of Austin car bodies such as degreasing and rustproofing, is carried out automatically by the Rotodip plant which processes

Fig. 4c (left)—Two very large oil-fired ovens in Tandem for window-frame manufacture. (Courtesy F. J. Ballard and Co. Ltd.).

approximately 22 bodies per hour. At a later stage the bodies are sent along an overhead conveyor, synthetic enamel is then sprayed on by operators. The enamel is then baked on in these steam-heated Carrier ovens operating at approx. 280° C. At Austin's it takes about half an hour for a car body to pass through the ovens.

Drying in Vitreous Enamelling

A firm which is entirely specialized in the vitreous-enamelling industry is Ferro Enamels Ltd., of Wolverhampton, belonging to a world wide concern with plants in U.S.A., Canada, Australia, and European countries. Among installations in this country the firm claims to have designed and installed the first continuous vitreous enamelling plant in the South, operating in the manufacture of refrigerators and using the continuous furnace.

Shortly after the introduction to the trade of the continuous burning furnace, the most modern shops realiezd that the fullest advantage could not be taken of a continuous furnace operation unless a continuous supply of dried ware was made available to the furnace. It is claimed that the use of a continuous dryer together with higher temperatures has permitted a material reduction in the time required for drying vitreous enamel coatings. In using room-type dryers, drying times as high as 30 to 40 min. are often encountered. On the other hand, with the
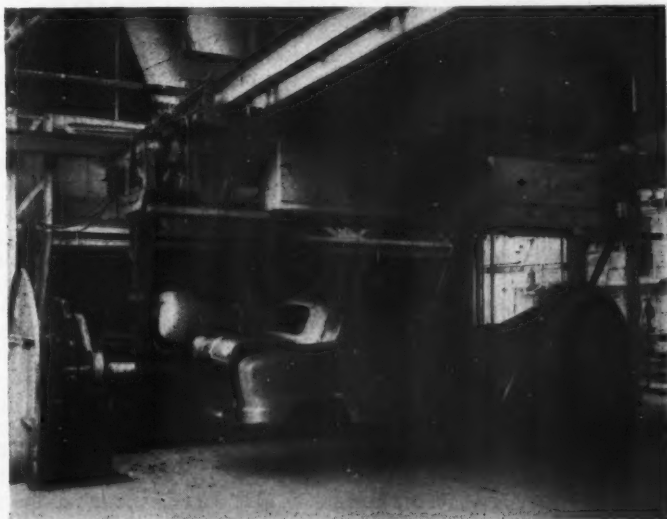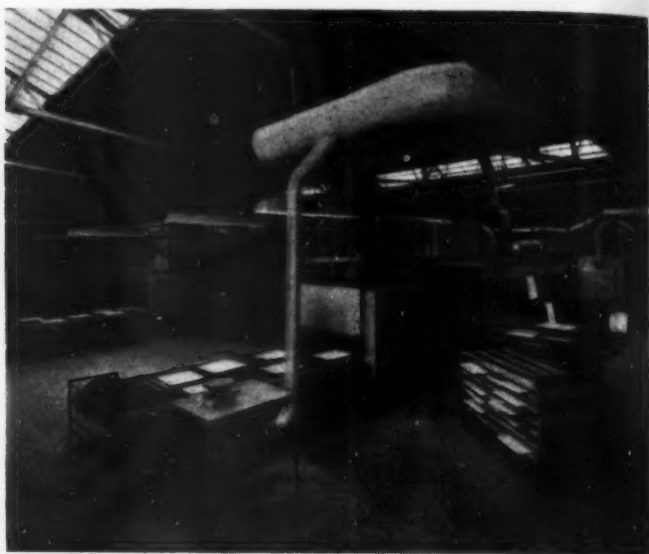

Fig. 5 (right)—Austin A.50 bodies entering rust - proofing Rotodip plant designed and manufactured by Carrier Engineering Co. Ltd. (Courtesy The Austin Motor Co. Ltd.).

Fig. 5b — "Laydown Type" of "Ferro - Ballard" convey dryers. (Courtesy Ferro Enamels Ltd.).

use of continuous dryers, it is not uncommon to encounter cases in which enamel coatings are being dried in 4 or 5 min. The continuous dryer has also contributed greatly towards the elimination of enamelling defects by minimizing the human factor.

There are three general types of "laydown" conveyor dryers, all of them operating on essentially the same principle with the exception that the moving hearth itself varies in design. These three types are pin-style, cable-style and the angle-style conveyors. Fig. 5a illustrates the arrangement of a "Ferro-Ballard" dryer with Monorail system. This and similar dryers are of the convection type and work at temperatures of 250 to 300° F. Fig. 5B illustrates a typical "laydown" conveyor dryer.

Generally speaking, the cable-style and the angle-style conveyors are employed for cover-coat work. In practically all cover-coat dryers an exchange system is devised so that the conveyor section which passes through the spray booth automatically places its load on a similar conveyor going through the dryers. This exchange is used in order to prevent the over-spray of enamel which is deposited on the conveyor from being dried and caked to the conveyor and thus causing operating difficulties, and also to conserve heat in drying. In nearly all cases the return system of the spray booth section of the conveyor is subjected to a water-spray as it returns underneath the spray booth before being reloaded.

Research Tests on Stoving

It has been mentioned before, that manufacturers of paints, lacquers and enamels carry out a great deal of research work in connexion with drying methods. The author is indebted to Pinchin, Johnson and Co. Ltd., of 4 Carlton Gardens, London, S.W.1, who have placed information on such tests regarding infra-red drying of paint films at his disposal. In the following, a few excerpts covering points of interest of paint users are given from an actual research report of this firm.

In order to assess the proportion of infra-red heat rays transmitted or reflected or absorbed by coated surfaces, tests have been carried out on the following objects: (a) a sheet of steel coated with flat black paint. These disclosed that this absorbs up to 99 per cent. of the radiation, the remainder (1 per cent.) being reflected. (b) A glossy white may absorb only 60 per cent. of the radiation, the remainder being reflected. (c) A sheet of bright tinplate coated with lacquer may absorb only 20 per cent. of the radiation. (d) A sheet of glass may absorb 10 to 20 per cent. of the radiation, the remainder being mainly transmitted.

During prolonged tests carried out with metal sheets coated with a stoving enamel, and subjected to infra-red rays, the enamel will eventually become baked hard. Baking time would, however, be shorter than in a convection oven, resulting from quicker heating-up of the panel. An actual specimen test took 8 minutes to reach 250° F in a convection stove, but only 45 seconds in an infra-red apparatus.

As a result of a number of actual tests on infra-red stoving, a diagram has been worked out showing the influence of the colour and gloss of the enamel used on the stoving time. It has been found that the effect of gloss seems to hinge on the transparency of the paint film to infra-red rays. As the gloss is increased, usually by reducing the percentage of pigment content, more infra-red rays pass unchanged through the film. It depends therefore upon the character of the undercoat or metal surface whether
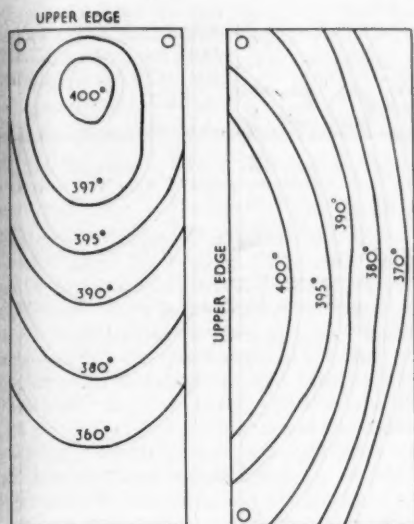
Fig. 6—Graph from test laboratory of Pinchin
Johnson and Co. Ltd., showing temperature distribution
on steel panels dried by infra-red.

these transmitted rays are absorbed and changed
into useful heat. The report shows that by using
a glossy white paint, with a darker background or
undercoat, a higher temperature is reached after
a certain stoving time than with a flat white.

Numerous tests carried out with various materials
and coatings to ascertain the normal baking times
and temperatures in a convection oven are useful to
stove manufacturers, especially when carried out
parallel with infra-red equipment. A diagram has
been produced to show maximum temperatures
which enamels will withstand without discoloration.
As most paint films will discolour when their
temperature is raised above a certain maximum,
tests of this nature are most useful. (In some
instances they may disclose limitations of infra-red
drying methods in favour of convection.) It is, of
course, well known that above a certain stoving
temperature damage may occur to objects being
baked, and tests can reveal this critical baking
temperature in each individual instance.

Several tests carried out by Pinchin Johnson and
Co. Ltd. deal with uniformity of heating, and with
reproducibility of results. Although an infra-red
stove may have been designed to produce a uniform
radiation, tests have revealed that it does not follow
that the radiated area of the plant is uniformly
heated. This applies equally to electric lamp
equipment with equally spaced lamps, as to the hot
wall of a gas tunnel. (Incidentally, a convection
stove may have "dead" corners where the hot air
does not penetrate.) Tests carried out by hanging
a small black panel in various sections of a small
lamp oven and in a gas tunnel respectively, disclosed

considerable temperature variations. For example,
the temperature may vary as much as 100° F over
the radiated areas. Convection currents set up may
also produce temperature variations between higher
and lower sections of larger hanging objects passing
through an oven. Fig. 6 illustrates drawings of
12-in. x 4½-in. steel panel test-pieces exposed to
uniform infra-red radiation in a lamp plant. It
shows the temperatures obtained in various parts of
a test-piece, in spite of uniformly spaced lamps.

Practical Tests with Convection Drying Plant

Paint drying takes place by evaporation, by
extraction or by polymerization. In practice many
paints dry by a combination of all three processes.
It can be safely assumed that many a drying plant
in actual use operates below its possible optimum
capacity, irrespective of which drying process is
applied, and convection stoving plants are no
exception. Efficient drying, however, can only be
secured by eliminating guesswork, by proper
training of plant operators, and by continuous
supervision of men and machines. To take guess-
work out of convection drying is obviously the most
important step, and this means availability of all
essential instruments. Some of them have to be
permanently installed, such as temperature re-
corders, draught indicators, operating time recorders,
etc. Other instruments have to be temporarily used
during actual efficiency tests, such as instruments
for measuring air speed at various oven locations,
or for measurement of power consumption of fan

Fig. 7—Single-pen operation recorder with drum chart
roll for checking conveyor - oven performance.
(Courtesy Evershed and Vignoles Ltd.).
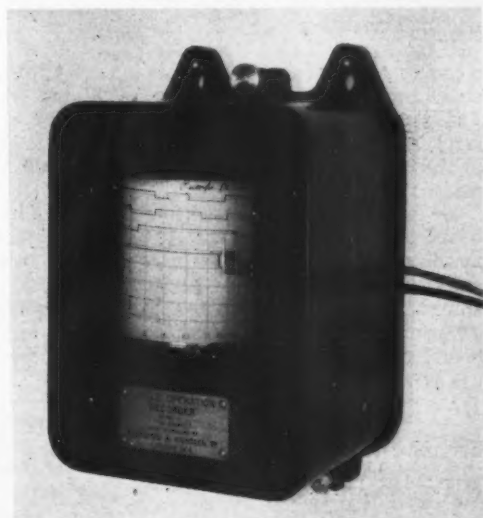
FINISHING POST

Advice on all aspects of metal finishing practice is offered on these pages, and while every care is taken to ensure the accuracy of information supplied no responsibility can be accepted for any loss which may arise in respect of any errors or omissions.

Motor Generators for Plating Plant; America replies to " Platelayer "

Dear Sir,

I was very much interested in a comment by "Platelayer" in your July, 1956, issue in your feature page "Talking Points".

Since we are manufacturers of the world's finest motor-generator sets which are used widely by the plating industry in this country, we take exception to the approach by your contributor.

For one thing, I believe that the plating industry is larger and heavier-duty than anything that you have in Great Britain and, secondly, because we are in a mass-producing plating industry we cannot afford to have any, even temporary outages that would be caused by failure of rectifying equipment when overloaded either accidentally or purposely for a short time in order to get out production.

The motor-generator set, as we manufacture it in this country, is a slow-speed, highly dependable, rugged, sturdy machine that will take regularly a 125 per cent. overload on a continuous basis and as much as 150 per cent. for reasonable periods of times without injury as well as it being a machine that provides power-factor correction, high efficiency, low maintenance and completely dependable power under all conditions of abuse as well as use.

If the author of this breezy note had ever seen a conveyor type of plating machine the size of that at Oldsmobile Division of General Motors at Lansing, Michigan—Chevrolet Motor Division of General Motors at Livonia, Michigan and others of like size, he would appreciate the power requirements for such installations.

He would then readily appreciate the desirability of the reliable motor-generator set for power. The machines are built in single units up to 20,000 ampères and in multiple units up to 80,000 ampères, as high as 24 volts and are not to be compared with the 5,000 ampère at 6 volt machines manufactured to the same design of twenty years ago as commonly used in England.

Very truly yours,
JAMES F. CARLAND.
Executive Vice-President and General Manager,
Chandeysson Electric Co.,
St. Louis, Mo., U.S.A.

Dear Sir,

I would refer to some comments by your contributor "Platelayer" in the July, 1956, issue of METAL FINISHING JOURNAL in regard to a large plating machine to be installed at the Ford Motor Company's plant at Monroe, Michigan.

The eighty motor-generator sets referred to are being furnished by our firm and his comments which were entirely misinformed are therefore of considerable interest to us.

In the first place the paragraph reading as follows:

"There are certain local conditions and State regulations in the U.S.A. which tend to favour generators as against rectifiers, but one would have thought that these might have been circumvented by now."

The statement has no foundation and could only be established under some extreme case where the design of the rectifiers might have a fire hazard. It certainly had no bearing on Ford Motor Company's selection of motor-generator sets. Further, rectifiers are quite extensively used by the Ford Motor Car Company as well as other large firms in those applications where they can be considered satisfactory.

I believe that your contributor is somewhat misinformed on the relative merits of motor-generator sets and rectifiers. As you undoubtedly realize there are millions of ampères of low-voltage d.c. power being supplied every year in this country from both motor-generator sets and rectifiers and these are being purchased by firms who are fully qualified to evaluate the comparative merits.

Rectifiers have been used extensively in this country for these applications since the late '30's so that there has been ample opportunity for these users to determine the comparative performance.

There are several pertinent points of difference which I believe exist.

1. The motor-generator set as manufactured in this country is a far more durable and dependable piece of machinery than has been available manufactured in England or Europe.
2. Duty cycles and production demands I believe are far more severe and represent thereby a greater test of the durability and dependability of the equipment.
3. The power demand such as that involved on the Ford installations are so great that the inherent higher efficiency of the motor-

generator set can be evaluated at a substantial saving, as well as the savings from the inherent power-factor direction of the synchronous motors used as standard to drive plating generators.

It may be a matter of further interest to you that English-made rectifiers have been actively promoted in this country by prominent electrical manufacturers and their characteristics and performance have therefore been compared and evaluated with American-made rectifiers.

Even at substantially favourable price advantages, I know of no major installations or others of any consequence that have made use of the English product which rather definitely establishes the fact that this has no advantage over American made rectifiers.

As a matter of fact I believe that you will find at this time that the American manufacturers are moving far ahead of all others in the use and application of germanium- and silicon-type rectifiers which we believe will rapidly supersede selenium.

I would be very happy to provide you with any further statistics or information which may be of value to establish the fact that such large users as Ford Motor Company, General Motors Corporation, U.S. Steel Corporation and thousands of others who are continuing to use motor-generator sets in increasing amounts for their needs are well qualified to establish the comparative merits between this and static rectifiers.

<div align="center">

Yours very truly,

GORDON J. BERRY.
</div>

President,
The Electric Products Co.,
Cleveland, Ohio, U.S.A.

<div align="center">

✶   ✶   ✶
</div>

It would be interesting to record the views of manufacturers and users of both types of electrical supply equipment in the U.K.

"Platelayer" has commented as follows:

May I say in the first instance, that these most informative letters must be of considerable interest to anybody faced with the problem of deciding on power supplies for electroplating.   It certainly clears up a number of points regarding the Ford Motor Company's decision to install generators as against rectifiers, which to anybody in this country would seem to be a retrograde step.

Mr. Berry does, however, repeat certain ideas about the electroplating industry in the United Kingdom which are current in America, which are not strictly in accordance with the facts.

(1) British made motor-generator sets are in no way inferior to those made anywhere in the world;

I am sure that any suggestions to the contrary would be readily disproved by the leading British electrical manufacturers whose names are household words even in the United States. Neither is there any reason to believe that requirements of electrical equipment in the many big installations in this country are any less severe than those prevailing across the Atlantic.

(2) In this country there is no tendency whatsoever towards the use of motor-generators; the first American-designed electrotinning lines installed in South Wales were powered by generators, but rectifiers are being used in the newest plants, presumably after careful consideration.

My remarks were not intended to claim that there was anything inherently superior about British rectifiers as compared with American ones; developments on selenium and germanium are also proceeding in this country and I agree with Mr. Berry about their future prospects which will further favour the use of rectifiers.

The fact remains, however, that in this country it is an incontrovertible fact that motor-generators (which require first-class maintenance if high efficiencies are to be consistently obtained) are no longer considered to be serious rivals to rectifiers of one kind or another for electroplating.   Neither Mr. Berry nor Mr. Carland entirely explains away this remarkable divergence between British and American practice.

Preplated Sheet and Strip

12117.   We were interested to read the enquiry concerning a source of supply of chromium-plated brass strip published in your August issue, and note your reply to the effect that such material is not manufactured in this country. You refer however, to the manufacturers of electrocoated sheet and strip, and we would be interested to learn the names of these manufacturers and the range of their products. In the course of a recent visit to the U.S.A. we learned of the apparent availability in that country of a wide range of metals finished in a great variety of coatings, but we have been unable to find any comparable supplies in the U.K.

The present position concerning the supply of pre-coated sheet and strip is that as far as can be ascertained, the following only are available: Tin-coated steel, both hot-dip and electrolytic, zinc-coated steel, both hot-dip and electrolytic, nickel plated and polished steel, brass, copper or chromium coated steel, and nickel, brass, copper or chromium coated zinc. There is also a certain amount of lacquered steel strip to be had. The names of the suppliers of these materials have been forwarded to the enquirer, whose comment concerning the difference in the supply position of these materials in the U.K. and the U.S.A. is certainly pertinent.

MECHANIZATION of •

• ORGANIC FINISHING LINE

at an American Works

Described by Herbert S. LEO*

ORGANIC coatings of improved quality are being applied to sheet-metal products with unprecedented economy by means of an automatic finishing line now in operation at the works of the Utility Appliance Corporation, Los Angeles.

The line was established in the course of a recent expansion programme which primarily involved the addition of 105,000 sq. ft. to 2,000,000 sq. ft. of floor space in the main plant. Because the building containing the extra space was erected adjacent to the existent factory structure, it was possible to install most of the finishing facilities in a new plant area in such a way as to maintain a smooth flow of production from fabrication and sub-assembly departments to the coating line—and from there to final assembly, warehousing, and shipping stations—without moving expensive machinery installations whose continued use of which was desirable.

The fabrication and assembly departments were subsequently expanded in the space left by the old finishing set-up, the facilities of which were completely discarded, and in areas once used for final

assembly, warehousing, and shipping purposes (since equivalent areas were made available in the new building).

The present finishing operation actually starts in the old building, where two heavy-duty conveyors are loaded with parts flowing from the sub-assembly departments. From the load-on point, the conveyors rise and within a very short distance pass through specially designed double fire doors into the new building.

Next, the conveyors make a 90-degree turn and enter a five-stage Bonderite machine—a double tunnel unit with a clear opening 5 ft. wide by 7 ft. high on each side. One monorail conveyor passes through each side of the machine, which is 108 ft. long.

In sequence, each Bonderizing tunnel comprises a 10-ft. approach section, a 12-ft. hot alkaline wash, a 10-ft. drain section, a 12-ft. rinse followed by a second 10-ft. drain, a 12-ft. coating unit, a third 10-ft. drain, a 6-ft. cold rinse followed by a fourth 10-ft. drain, and finally a 6-ft. chromic rinse section followed by a fifth 10-ft. drain.

Each tunnel of the Bonderite machine is equipped with its own burners, controls, etc., so that it may be independently operated when necessary.

Parts on either conveyor leaving the Bonderite machine pass almost immediately into a double dry-off oven, which operates at a temperature of approximately 400° F. At average conveyor speed, the Bonderized parts are

* Vice President and General Manager, Utility Appliance Corporation, Los Angeles, Calif., U.S.A.
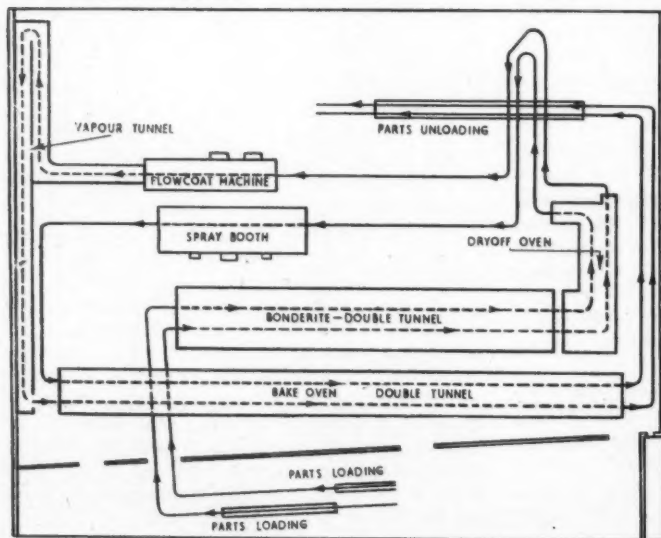
Fig. 1.—Diagrammatic representation of the floor layout of the new organic finishing line installed at the works of the Utility Appliance Corporation.

Fig. 3 (below).—*After leaving the Bonderizing tunnel and dry-off ovens components are conveyed through conveyor lubricators near the roof trusses and return to floor level for spray painting or flow coating.*

Fig. 2 (above).—*Twin conveyors seen on the right convey components from the old building through double fire doors and turn at right-angles into a five-stage double-track Bonderizing tunnel.*

subjected to the latter temperature for approximately 4½ minutes.

Leaving the dry-off oven at different positions, the two conveyors rise near the roof trusses where they pass through automatic lubricators.

One conveyor then drops down and passes through a 45-ft. De Vilbiss water-wash spray booth, where parts may be sprayed with any one of six different paints pumped through a circulating system from a nearby storage room.

The second conveyor drops down to a tandem flow coater, which has the same opening as the Bonderite machine, through an 8-ft. approach section, then it goes through a 4-ft. flow-coating chamber and an 8-ft. drain and drip-off area.

The tandem arrangement of the flow coater next provides a second 8-ft. approach, 4-ft. flow-coating chamber, and 8-ft. drain and drip-off area (which can be operated alternately, but not simultaneously). The primary function of this double-tandem set-up is to provide for rapid changeover of colours; it also provides standby equipment in the event of a break-down in either coating chamber.

Paint and thinner for the flow-coater tanks are pumped from an adjacent paint room which is

separated from the storage room provided for spray booths.

After leaving the 8-ft. drain and drip-off area in the flow-coater proper, parts are conveyed through a long drip-off housing and vapour tunnel which provides for approximately 15 minutes of paint flowout before they enter a bake oven.

Parts that have been spray painted are carried from the exit end of the booth to an elevated position and, after travelling some distance, they also enter the bake oven. At this point the two conveyors are again paralleled to one another.

The paint baking oven is of the double-tunnel type with clear openings similar to those of the Bonderite machine. Operating temperatures of 450° F are commonly used, but there is an adequate factor of safety if higher baking temperatures are required for special finishes. The 178-ft. length of the oven allows enough time for proper curing of all finishes now used.

Parts with finishes requiring different curing temperatures on the two conveyors may be either simultaneously or alternately passed through the heating unit because each side of the bake oven is
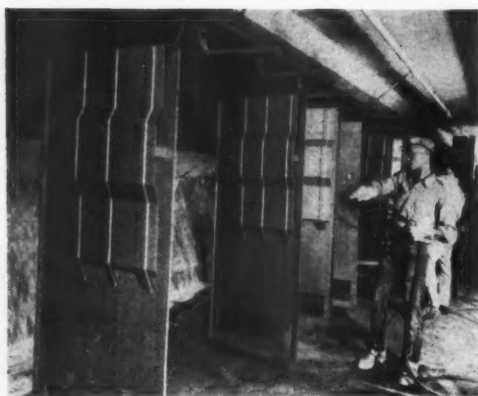
Fig. 4 (above).—*Components are shown passing through the spray-booth portion of the new finishing line.*

Fig. 5 (right).—*Components are shown entering the flow-coat line.*
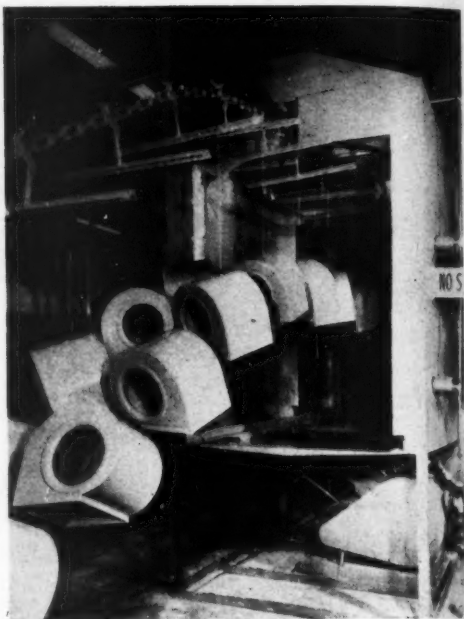
equipped with its own burners, controls, blowers, and related accessories.

After leaving the elevated oven, parts on both conveyors travel in an elevated position for a considerable distance before they reach the conveyor take-off level. This allows the parts plenty of time to become cool, so that they can be safely handled when the conveyors are unloaded.

Because paint applied with the flow-coater may serve as either a finish or a primer coating, the conveyor take-off point was located so that parts which have been flow-coated and baked can be transferred to the spray finishing conveyor when-

ever necessary at a station near the entrance to the spray booth.

This fully-conveyorized system has replaced one which was only partly conveyorized. The latter includes a trichlorethylene degreaser, individual 8-ft. spray booths, paint dip tanks and a U-type conveyorized paint bake oven.

Following removal from a conveyor, finished parts and sub-assemblies go to five new parallel, mechanized flat conveyors so that they can be incorporated in furnaces, heaters, air conditioners, and blowers made by the company. Before leaving the latter conveyors, the assembled products are tested and packaged. Then they are grouped together and pulled by means of an electric tugger into the warehouse area.
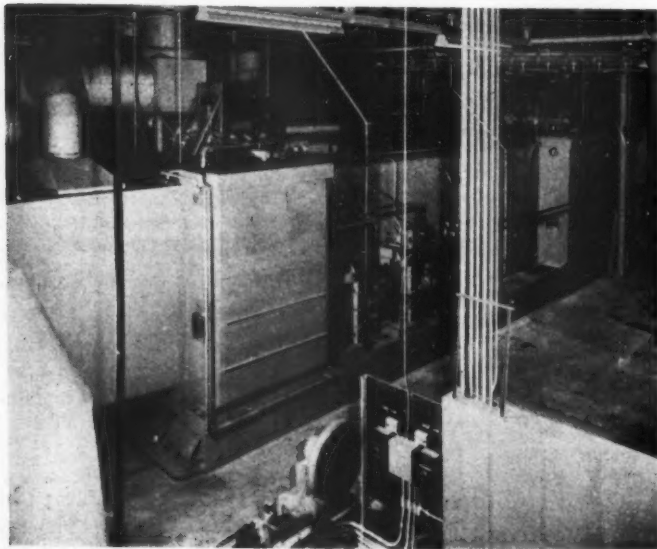
Fig. 6.—*General view of the double-track stoving line.*

"AN EYE FOR COLOUR" ●

● *Details of an Acceptable Colour Standard and the Means of Achieving it*

By

**E. W. DUNNING, B.Sc.,
A.R.I.C., M.Inst. Gas. E.** [*]

Introduction

TWENTY per cent. of all gas cooking appliances become chipped somewhere before being accepted by the customer (over 100,000 parts per annum), a problem which has already been discussed at previous meetings ([1], [2]). The ancillary problem of colour matching has not been considered so fully, and is of great importance here, where the replacement part must match as nearly as possible the rest of the new cooker in order for the customer to be satisfied. Although the cooker may have been selectively assembled in the factory, and in any case is finally inspected for appearance by a person unconnected with the enamelling process, replacement parts, which should, of course, be as near the standard colour as possible, are not usually examined in this way.

Recently the Institute of Vitreous Enamellers, in conjunction with the Vitreous Enamellers Association and the Society of British Gas Industries, have agreed with the Gas Council a code of acceptance for vitreous-enamelled appliances and parts. It has, however, been impossible for any party even to suggest a code of acceptance for colour. The investigation described in this paper is an attempt to solve some of the problems, and perhaps after discussion at this conference some code can be formulated.

A number of enamellers have specially produced collections of enamelled plaques of varying tints[†] to enable Gas Board inspectors to assess them. These different plaques (254 in all) have been obtained by varying a number of factors including the enamel composition, fusing temperature and fusing time. Thus it has also been possible to indicate the principal causes of colour differences.

[*] Gas Council, Watson House Centre, London, S.W.6
[†] All colour terms conform to B.S.1611 "Glossary of Colour Terms used in Science and Industry".
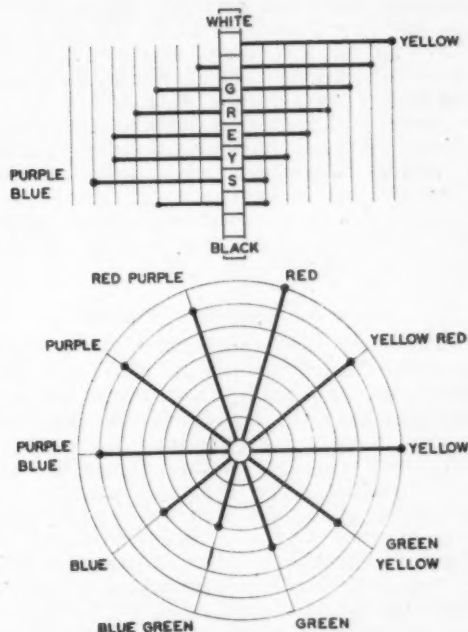
Fig. 1.—Variation in saturation with hue.

Colour Standards and Colour Differences

Much has been written on the subject([3], [4]) and a paper on the subject of colour measurement has recently appeared in the Bulletin([5]). Colour can vary in three main ways, first, "hue" or the rainbow effect, second, "value" or "lightness" from white to black through any particular hue, and third, "chroma" or "saturation" from neutral grey through progressively brighter colours to the purest colour possible. An elementary way to represent this is by a sphere, the hue being distributed round the equator with greys of various degrees on the central axis, with white at the North Pole and black at the South Pole. In practice some colours can be produced in greater degrees of saturation than others; for example, reds more than greens and also

the brightest or more highly saturated yellows are lighter, *i.e.*, in the northern hemisphere, while the brightest greens and blues are darker, *i.e.*, in the southern hemisphere. The actual shape of the solid is thus distorted as in Fig. 1. Any actual colour can thus be identified with a particular point in the solid, although very rarely on the surface itself which is reserved for the purest colours obtainable. Variation from any selected colour can thus vary in three directions simultaneously and there are many colours which are slightly removed from the selected one. It is therefore impossible to specify a high and low limit or other equally simple notation. It is, however, possible that in practice vitreous enamel does not vary so much in some directions as in others, and this may simplify an almost insoluble problem. Some simplification is obtained in that the matching is done on like surfaces, *i.e.*, glossy vitreous enamel, and not on dissimilar ones such as vitreous enamel and a fabric. Colour-measuring instruments are also more satisfactory in detecting differences than in defining actual colours, particularly differences in the lighter pastel tints, which are the types of colour most usual in vitreous enamel for household equipment.

Visual Assessment of Plaques

A detailed assessment was made by 46 individuals in various centres on six of the twelve area Gas Boards, who compared 71 vitreous-enamelled sheet-steel plaques supplied by manufacturer A with a standard plaque. Each plaque was checked individually against the standard, by viewing both together at right-angles to the surface, with the illumination at an angle of 45 deg. The findings were put into four categories—perfect match, acceptable, doubtful and reject. A pass result was assessed as one where over 80 per cent. of the plaques were classified as perfect match or acceptable. A near pass was assessed as 80-35 per cent. acceptable, and a fail where less than 35 per cent. were grouped as acceptable, *i.e.*, over 65 per cent. of the observers considered the plaque either a reject or doubtful. In order to examine the results statistically the plaques were scored as follows: 3 perfect match, 2 acceptable, 1 doubtful and 0 reject, and total scores were obtained.

One group of eight observers from one Board examined the plaques under three separate lighting conditions. First, a Siemens Industrial colour matching unit, having a spectral distribution approximating as closely as possible to natural daylight and having an illumination intensity of about 50 lumens per sq. ft. was used. This lighting unit contained two 2-ft. 40-watt blue fluorescent lamps and two 60-watt pearl single-coil gas-filled tungsten-filament lamps. Second, the fluorescent light only was switched on, giving an illumination of about 40 lumens per sq. ft. and last, the tungsten-

filament lamps alone were used, giving an illumination of about 25 lumens per sq. ft.

The type of lighting employed appears to have a definite effect on the subjective assessment of plaques and, on the average, observers are not so stringent when viewing in daylight, the appropriate scores being Daylight 696, Tungsten 589, and Fluorescent 605. A further, somewhat surprising, fact is that subjective assessment by different observers is affected in different ways by the types of lighting. For example, one observer returned the same scores for tungsten and fluorescent but was more lenient under daylighting, the corresponding scores being 137, 91, 91. On the other hand another observer was more stringent under tungsten lighting, the corresponding scores being 65, 35, 65. However, the variation due to the effect of lighting was smaller than that due to the other design variables.

It is necessary to have adequate illumination in order to discriminate between different colours. High intensity does not, however, increase the discrimination. It has been suggested that it is more difficult to assess differences in bright sunlight, as on taking a range of similar colours into bright sunlight the first impression is that there is less difference than in diffused daylight. However, this appears to be due to a sudden contraction of the pupil of the eye, for after a time the differences are again apparent. In a similar manner it was found in artificial light that after a change from one illumination to another a period of adjustment of the eye was necessary.

The assessments carried out by other Boards were made under various forms of artificial light or diffused daylight. In view of the special investigation above, all the results were considered together. Fig. 2 shows the average result, and the results obtained by considering each Board separately. It

Fig. 2.—Assessment of one set of plaques by a number of Boards.

AV.	1	2	3	4	5	6
15·3	4·2	13·9	13·9	20·8	23·6	15·3
	15·3					
		16·7				
35·2				38·9	30·6	
						32·0
	80·5	69·4				77·8
49·5				47·2	48·6	44·4
						6·9

□ PASS   ▨ NEAR PASS   ■ FAIL
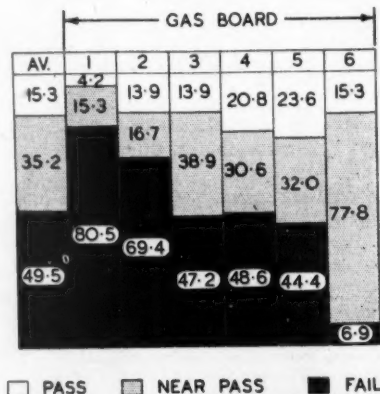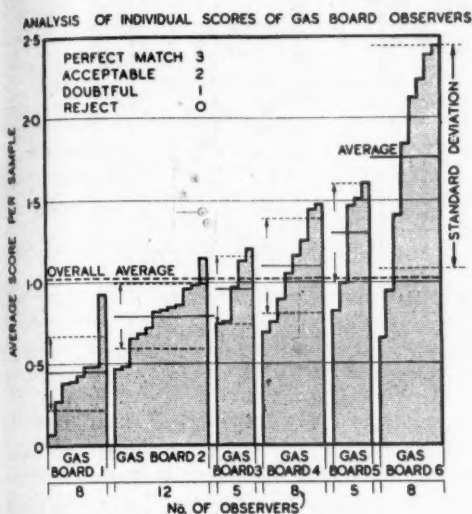
Fig. 3.—*Analysis of individual scores of Gas Board observers.*

Fig. 4.—*Comparison of observers from Gas Board 4 for the assessment of different sets of plaques.*

will be seen that three Boards gave very similar results, and a statistical examination showed that the average result for each of the other three was significantly different from the overall average. One Board was very much more severe in its assessment, and yet another was particularly lenient. Fig. 3 shows the individual assessments. Only one-third of the observers gave scores within ±20 per cent. of the mean, but two-thirds were within ±50 per cent. One individual only passed 5 per cent. of the plaques while at the other extreme another passed 92 per cent. It appears that some training in assessment would considerably reduce the spread of results.

Plaques were also submitted from four other sources; there were four sets of sheet steel in different cream tints and two sets of cast iron, one cream and one grey. These were examined only by the eight observers of Board 4; fortunately these observers on the previous trial had given an average result nearest to the combined average result of all Boards.

Fig. 4 shows the average score of each observer for each set of plaques. It will be seen that two observers gave scores within ±20 per cent. of the

mean for all sources. One observer was consistently more severe in his assessment than the other and one more lenient. In general the higher the average score for the sets of plaques, *i.e.*, the more acceptable, the better the agreement between observers.

One supplier (E) of plaques carried out an

Fig. 5.—*Comparison of assessment of Gas Board 4 with Maker E.*

TABLE I

	Gas Board 4		Maker B	
	Number	Per-centage	Number	Per-centage
Pass	14	26	7	13
Near Pass ...	22	41	14	26
Fail	18	33	33	61

Fig. 6.—*Correlation of Eel colorimeter with visual observation; plaques by Maker A.*
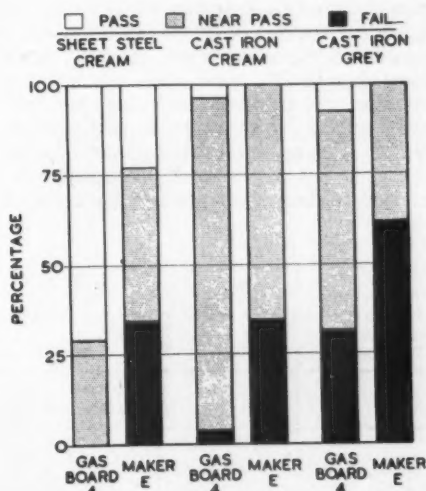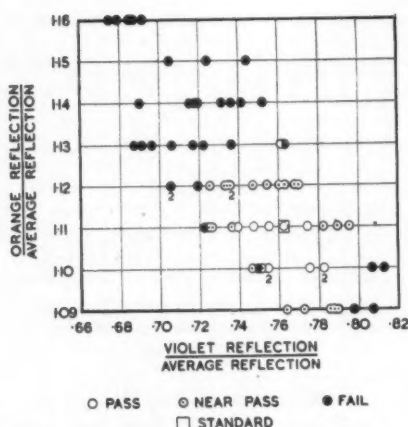
Fig. 7.—*Correlation of Hunter colorimeter with visual observation; plaques by Maker A.*

examination using both daylight and artificial light by eight personnel, five of them trained in enamel inspection. Fig. 5 compares the average result obtained with that obtained by the eight observers in Gas Board 4. Another supplier (B) gave results found with eight trained inspectors and Table I compares these results with those obtained by the same eight Gas Board inspectors with the same plaques.

In both cases the manufacturer is very much more critical than the Gas Board inspectors.

In all over 11,000 separate assessments were made.

Physical Assessment

Colour patterns can be used for fixing and describing any particular colour and the Munsell system[6] is that most generally used. Colour patterns however can only vary by discrete amounts, and also this method is least satisfactory with very light colours, which are those generally used for domestic appliances.

Colorimeters, using colour filters and photo-electric cells for measuring the transmission or reflection of light, give a measurement on a meter once they have been calibrated and therefore do not need such skilled observers also having average

colour response. Measurements have been made with two instruments; one, the Eel[7], measures the reflectance of light from the sample through nine filters ranging from violet to red, the other, the Hunter colour difference meter[8], uses two pairs of complementary filters and fixes a point on the green-neutral grey-red scale and another point on the yellow-neutral grey-blue scale. These two together fix the colour.

It is difficult to decide how to plot the Eel results in which nine results are obtained for each plaque. Fig. 6 shows the peak reading (orange filter) divided by the average reading for all nine filters plotted against the minimum reading (violet filter) again divided by the average reading. The plotted points have been distinguished to show their visual assessment by Gas Board 4. The "pass" results are well grouped around the standard and except for one point the "fail" results are well separated from the "pass" results. Fig. 7 shows the same plaques using the Hunter instrument. Again the "pass" results are grouped around the standard and the "fail" results well separated although the agreement with visual assessment is not quite as good. Fig. 8 shows the results obtained for another set of plaques using the same observers. The agreement between

TABLE II

Designation	801	12U1	9N2	1N2	4N1	9U2
Classification	Pass	Pass	Dark near pass	Dark near pass	Dark fail	Light fail
Colour ...	Yellow	Pink yellow	Pink yellow	Yellow	Yellow	Pink yellow
Score ...	51	46	32	29	11	8

TABLE III

Meter belonging to Maker	801	12U1	9N2	1N2	4N1	9U2
A	1·75	2·21	2·72	3·86	4·44	4·40
D	1·14	1·71	2·61	3·10	3·51	3·13
F	2·18	1·0	2·28	3·72	3·67	2·28

instrument and visual assessment is not as good as in Fig. 6.

Some plaques supplied by manufacturer A were examined on three different Eel instruments. The plaques chosen in addition to the standard are shown in Table II.

12U1 and 9N2; 1N2 and 4N1 are pairs of plaques exhibiting a suspected small colour difference. The first plots using the meter belonging to manufacturer A appeared to place the plaques correctly. Part of the operation was to see if other meter readings might reverse the plots so that, for example, 9N2 would be plotted with the passes and 12U1 with the near passes.

Appraisal of the results showed that the colour meters are subject to systematic errors (*e.g.*, reading high), so that unless some correction were applied, the results for one set of plaques read with one meter could not be combined with the readings of a different set of plaques read with another meter. However, since comparisons are being made with a standard it should be possible to eradicate the effect of systematic errors.

A first analysis of the results used the same method as that adopted previously, *i.e.*, peak and minimum readings divided by the average reflectance, to obtain weighted readings. The weighted reading of the standard was then subtracted from each plaque (treating the results for each meter separately) to give a colour difference for peak and minimum. These differences were then squared, added, and the square root taken to give the radius vector of the colour difference from standard. This colour difference is shown in Table III.
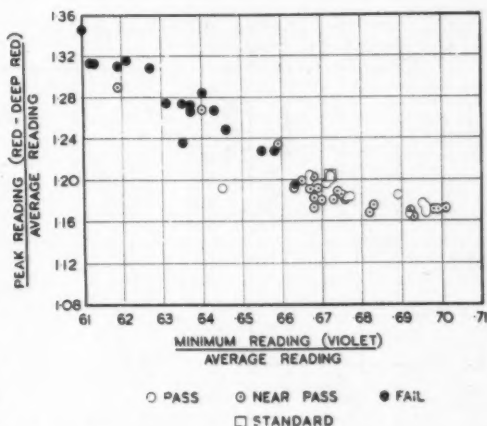
Fig. 8.—*Correlation of Eel colorimeter with visual observation; plaques by Maker B.*

It can be seen that 9N2 figures are always greater than those for the corresponding 12U1 as was to be expected. This holds true for 4N1 and 1N2 except that a "reversal" occurs with the F meter (3·72 ⟷ 3·67). All of the results for 12U1, 9N2, 1N2, 4N1, 9U2 are greater than the corresponding 801 reading except in one not so important F reading (2·18 ⟷ 1·0). The 9U2 figures are higher than the 12U1 and 1N2 figures, as they should be, except for one F reading (3·72 ⟷ 2·28).

The unsatisfactory results obtained with the F meter might be due to the fact that meter readings were rounded off to whole numbers whereas the others were given to 0·2.

TABLE IV

Meter belonging to Maker	801	12U1	9N2	1N2	4N1	9U2
A	2·38	2·82	3·81	5·12	5·09	5·39
D	2·16	2·81	3·48	4·63	4·79	3·84
F	3·46	3·77	4·60	6·50	6·63	4·62

TABLE V

VARIABLES	A	B	C	D	E		
Material	Sheet steel	Sheet steel	Sheet steel	Sheet steel	Sheet steel	Cast iron	Cast iron
Colour	Cream	Cream	Cream	Cream	Cream	Cream	Grey
No. of covercoats	1 and 2	1	1	1	1 and 2	1	1
Total amount of colour added	4/5ths of standard Standard 6/5ths of standard	Changes in shade also varied the total colour Cream 112% Standard 100% Brown 112%	Standard	Standard	4/5ths standard Standard 6/5ths standard	4/5ths standard Standard 6/5ths standard	4/5ths standard Standard 6/5ths standard
Change and shade of colour	Yellow 60% 50% 40% 50% +10% added grey / Brown 40% 50% 60% 50%	Cream 56% 50% 44% / Brown 44% 50% 56%	20% more yellow Cream 10% more brown	Standard	Standard	Standard	Standard
Coloured frit or colour added as mill addition	Colour added as mill addition	Colour added as mill addition	Colour added as mill addition	Coloured frit compared with colour added as mill addition	Colour added as mill addition	Colour added as mill addition	Colour added as mill addition
Use of clay or electrolyte as suspension media	Clay	Clay or sodium silicate + sodium aluminate	Clay	Clay	Clay	Clay	Clay
Fusing temperature	780° C ±2° C 800° C ±2° C 820° C ±2° C	780° C 820° C 860° C	850	790° C 800° C 810° C 820° C 830° C 840° C	785° C ±5° C 805° C ±5° C 825° C ±5° C	785° C ±5° C 805° C ±5° C 825° C ±5° C	770° C ±5° C 790° C ±5° C 810° C ±5° C
Fusing time	3 min.	3, 4 and 5 min.	2 min. 3 min. 4 min.	5 min.	5½ min. 7 min. 8½ min.	33 min. 40 min. 47 min.	33 min. 40 min. 47 min.
Total number of samples 254	72	54	12	12	52	26	26

Manufacturer		Pass	Near Pass	Fail	Score
A Sheet steel Cream	1 coat 10·6 thou. thick	7	13	16	955
	2 coat 14·5 thou. thick	7	11	18	935
E Sheet steel Cream	1 coat 13·1 thou. thick	20	7	0	1,141
	2 coat 15·7 thou. thick	18	8	0	1,102

TABLE VI (left)

Results for 1 *and* 2 *coats*

Details		—20% Colour	Standard	+20% Colour
Manufacturer—A Sheet steel Cream	Pass	5	4	0
	Near Pass	9	7	2
	Fail	4	7	16
	Score	584	536	204
Manufacturer—E Sheet steel Cream	Pass	15	15	8
	Near Pass	3	2	10
	Fail	0	0	0
	Score	776	778	689
Manufacturer—E Cast iron Cream	Pass	1	1	0
	Near Pass	7	8	9
	Fail	1	0	0
	Score	282	345	271
Manufacturer—E Cast iron Grey	Pass	0	1	2
	Near Pass	2	3	3
	Fail	7	5	4
	Score	119	203	205

TABLE VII
(right)

As a further experiment the above procedure was repeated using all filter readings to give a colour difference in "9 dimensions" instead of two. The root-mean-square comparisons obtained are shown in Table IV.

Again 9N2 figures are greater than those for the corresponding 12U1. In the case of 4N1 and 1N2 "reversal" occurs for the A meter. 801 readings are always smaller than those for the other corresponding plaques and the reversal noted earlier does not take place with this analysis.

On the other hand, while 9U2 figures are higher than 12U1 they are lower than 1N2. There is, of course, no reason *a priori* why a "light fail"

colour difference should be greater than for a "dark near pass", but such a state of affairs was to be hoped for.

Variation of Acceptance with Technical Changes in the Vitreous-enamelling Process

Table V shows the process changes that have been made to produce the variations in colour of the resultant plaques. The changes were purposely made larger than those that might take place in actual practice to be sure of obtaining some plaques that would be rejected by all observers. The technical changes take the form of a "factorial" experiment and a detailed statistical analysis was made for the plaques provided by manufacturer A.

TABLE VIII
(right)

TABLE IX
(below)

		Yellow	Standard	Red
Manufacturer—A	Pass	2	6	1
	Near Pass	10	3	5
Sheet steel Cream 20% excess Yellow	Fail	6	9	12
20% excess Red	Score	467	532	328
Manufacturer—B	Pass	6	3	5
	Near Pass	6	11	5
Sheet steel Cream 11% excess Yellow	Fail	6	4	8
11% excess Red	Score	485	520	439
Manufacturer—C	Pass	2	3	0
	Near Pass	0	1	2
Sheet steel Cream 20% excess Yellow	Fail	2	0	2
10% excess Red	Score	120	214	72

		Standard	Grey added
Manufacturer—A	Pass	4	5
	Near Pass	7	6
Sheet steel Cream	Fail	7	7
10% excess Grey	Score	536	566

Manufacturer D Sheet steel Cream	Fusing Temperature °C						
	790	800	810	820	830	840	Total Score
Coloured Frit	Near Pass	Pass	Standard	Pass	Near Pass	Fail	202
Colour added at Mill	Near Pass	Pass	Standard	Near Pass	Fail	Fail	116

This took the form of an analysis of "variance", but only the effect of interactions likely to be of interest were studied. Further information is given in Appendix 1 (*see* page 434).

In the following sections the process changes have been considered separately. Eight observers (Gas Board 4) made the assessment.

1. *Number of Cover Coats*

Table VI compares a single cover coat with a double cover coat. It will be seen that there is no significant difference between them for either maker.

2. *Total Amount of Colour Added*

Table VII compares the effect of using either 20 per cent. excess colour or 20 per cent. less colour. With the two sheet-steel enamels it is only the excess colour which increases the rejection. On the other hand, with the grey cast-iron enamel the 20 per cent. reduction in colour appeared to have little effect. With the cream cast-iron enamel, both variations from standard caused some increase in rejection. This variation is affected by the temperature stability of the enamel.

3. Change of Shade of Colour

Table VIII compares the effect of changing the proportions of yellow and red or brown colour, the latter having a greater effect than the yellow. The effect of adding about 10 per cent. of grey colour had a negligible effect on the assessment.

4. Coloured Frit

Table IX compares the effect of using coloured frit with the more usual practice of adding the colour as a mill addition. In each case plaques were fired at a range of temperatures and the plaque fired at 810° C taken as standard. It will be seen that the coloured frit is more stable to overfiring than the normal frit.

An improved colour stability with variation in fusing temperature has also been reported by British Titan Products Co. Ltd.[9].

5. Use of an Electrolyte instead of Clay as Suspension Media

Table X shows that the use of an electrolyte decreased the acceptable number of plaques.

6. Fusing Temperature

Table XI shows the effect of variation in fusing temperature with four types of cream sheet-steel enamel and two colours of cast-iron enamel. An

TABLE X

		Clay	Electrolyte
Manufacturer B ...	Pass	13	1
Sheet steel	Near Pass	6	16
cream	Fail	8	10
	Score	842	602

increase in fusing temperature with sheet steel enamels had a greater effect than a decrease in temperature. With cream cast-iron enamel the total effect was less marked and there was little difference between an increase and a decrease in fusing temperature. On the other hand the grey enamel seemed particularly sensitive to temperature and there was a marked reduction in acceptance, particularly with over-firing. Some of the colour change is due to the use of titanium oxide as an opacifying material. A colour change from bluish white to yellowish white has been shown [10, 11] to be due to a change in crystalline structure.

In view of the effect of quite small changes in temperature, it is surprising that little information appears to be available on the variation of actual temperature of the enamel with position in the furnace. Furnace pyrometers also seem to have a much less open scale than need be, as the range of temperatures used is much smaller than the range on the average pyrometer.

		−40	−20	N	+20	+40
Manufacturer—A	Pass		5	6	3	
	Near Pass		9	10	5	
Sheet steel Cream	Fail		10	8	16	
	Score		476	523	323	
Manufacturer—B	Pass	6		8		0
	Near Pass	11		9		2
Sheet steel Cream	Fail	1		1		16
	Score	615		696		133
Manufacturer—E	Pass		13	13	12	
	Near Pass		5	4	6	
Sheet steel Cream	Fail		0	0	0	
	Score		759	743	741	
Manufacturer—E	Pass		0	1	1	
	Near Pass		8	8	8	
Cast iron Cream	Fail		1	0	0	
	Score		293	328	277	
Manufacturer—E	Pass		1	2	0	
	Near Pass		4	4	0	
Cast iron Grey	Fail		4	3	9	
	Score		189	279	59	

TABLE XI
(left)

7. *Fusing Time*

Table XII shows the effect of variation in fusing time. With sheet steel enamels a 25 per cent. increase or decrease had little effect although it must be remembered that this increase only amounts to one minute on the short fusing time. A smaller percentage variation of 17 per cent. with cast iron enamel had a much greater effect, especially with the grey colour, but owing to the longer fusing time with cast iron the actual variation in time, of 7 minutes, was greater. The effect of fusing time is somewhat similar to that of fusing temperature, as is to be expected, and though, in the range of variables considered, variation in time is not so critical as of temperature the pattern of Table XI is repeated in Table XII.

8. *Compensating Effects*

Table XIII shows the assessment of one set of plaques. From this it can be seen that over-firing can be compensated by a reduction of added colour, and under-firing by an increase in added colour.

TABLE XII

		Fusing Time, min.		
		3	4	5
Manufacturer—B	Pass	3	6	5
	Near Pass	9	6	7
Sheet steel Cream	Fail	6	6	6
	Score	502	493	449
		Fusing Time, min.		
		2	3	4
Manufacturer—C	Pass	1	3	1
	Near Pass	—	2	1
Sheet steel Cream	Fail	1	—	2
		Fusing Time, min.		
		5½	7	8½
Manufacturer—E	Pass	14	12	12
	Near Pass	4	5	6
Sheet steel Cream	Fail	0	0	0
	Score	753	738	752
		Fusing Time, min.		
		33	40	47
Manufacturer—E	Pass	1	1	0
	Near Pass	8	8	8
Cast iron Cream	Fail	0	0	1
	Score	315	319	264
Manufacturer—E	Pass	0	2	1
	Near Pass	4	3	1
Cast iron Grey	Fail	5	4	7
	Score	155	225	147

Conclusions

Although there was a wide difference between the acceptance standard with extreme observers, there was reasonable agreement among the majority. The manufacturers' standard appears to be higher than that of Gas Boards. There was good correlation between observers' assessment and physical assessment with two types of instrument. It is reasonable to assume that the agreement between observers would be much better if they were given standards of acceptance instead of having to estimate their own variation in colour for non-acceptance. It is easier to determine acceptance co-ordinates with a physical test method than to provide the large number of different coloured samples that are necessary to define the variation by the visual matching method. It must, however, be realized that it is the visual assessment that is the final arbiter. Unfortunately it is impractical to have either a colorimeter or a mass of coloured plaques at every receiving depot. Better control by the manufacturer, particularly for spare parts, working to agreed limits appears to be the best solution with occasional checking by Gas Boards with adequate technical facilities.

The variables in enamel production have been considered and some of these may be compensating. Variation in fusing temperature, and perhaps fusing time, seem the more important, although the production of frits which can be used over a wide temperature range without change of colour will minimize this effect.

		1 COAT			2 COATS		
		Underfire	Normal fire	Overfire	Underfire	Normal fire	Overfire
Yellow cream		Pass	Near Pass	Fail	Near Pass	Near Pass	Fail
Cream	Normal	Pass	Standard	Near Pass	Near Pass·	Pass	Fail
Red cream		Near Pass	Near Pass	Fail	Fail	Fail	Fail
Yellow cream		Near Pass	Fail	Fail	Near Pass	Fail	Fail
Cream	+20%	Fail	Fail	Fail	Fail	Fail	Fail
Red cream		Fail	Fail	Fail	Fail	Fail	Fail
Yellow cream		Near Pass	Near Pass	Near Pass	Near Pass	Pass	Near Pass
Cream	—20%	Fail	Near Pass	Pass	Fail	Pass	Pass
Red cream		Fail	Near Pass	Near Pass	Fail	Near Pass	Pass
Yellow cream		Near Pass	Fail	Fail	Fail	Near Pass	Fail
Cream	+10% grey	Pass	Pass	Fail	Pass	Pass	Near Pass
Red cream		Pass	Near Pass	Fail	Near Pass	Near Pass	Fail

TABLE XIII (above)   TABLE XIV (below) *Analysis of Variance*

Source of Variation					Sum of Squares	Degrees of Freedom	Mean Square	Value of F	Significance
Main effects:									
Observers	...	...	...	...	107·3	7	15·3	23·3	V. Sig.
Coats	...	...	...	...	1·6	1	1·6	2·4	
Lights	...	...	...	...	5·8	2	2·9	4·4	Sig.
Oxides {linear		...	...	...	167·1	1	167·1	254	V. Sig.
Oxides {quadratic		...	...	...	32·4	1	32·4	49·3	V. Sig.
Colours {linear		...	...	...	22·4	1	22·4	34·1	V. Sig.
Colours {quadratic		...	...	...	27·9	1	27·9	42·5	V. Sig.
Firings {linear		...	...	...	27·1	1	27·1	41·2	V. Sig.
Firings {quadratic		...	...	...	25·5	1	25·5	38·8	V. Sig.
Two-factor interactions									
L$_{col.}$	L$_{ox.}$	...	...	...	2·8	1	2·8	4·3	
L$_{col.}$	Q$_{ox.}$	...	...	...	0·67	1	0·67	1·0	
Q$_{col.}$	L$_{ox.}$	...	...	...	2·8	1	2·8	4·3	
Q$_{col.}$	Q$_{ox.}$	...	...	...	64·9	1	64·9	9·9	Sig.
L$_{fir.}$	L$_{ox.}$	...	...	...	116·5	1	116·5	177·3	V. Sig.
L$_{fir.}$	Q$_{ox.}$	...	...	...	47·0	1	47·0	71·5	V. Sig.
Q$_{fir.}$	L$_{ox.}$	...	...	...	13·2	1	13·2	20·1	V. Sig.
Q$_{fir.}$	Q$_{ox.}$	...	...	...	21·1	1	21·1	32·1	V. Sig.
L$_{fir.}$	L$_{col.}$	...	...	...	35·0	1	35·0	53·3	V. Sig.
L$_{fir.}$	Q$_{col.}$	...	...	...	18·8	1	18·8	28·6	V. Sig.
Q$_{fir.}$	L$_{col.}$	...	...	...	0·67	1	0·67	1·0	
Q$_{fir.}$	Q$_{col.}$	...	...	...	1·9	1	1·9	2·9	
Three-factor interactions									
Obs. x Coats x Lights	...	...	...		6·4	14	0·457	0·7	
Ox. x col. x fir.	...	...	...		21·6	8	2·7	4·1	V. Sig.
Other three-factor interactions plus higher order interactions plus error			...	...	803·3	1,222	0·657		
TOTAL	...	...	...	...	1,294·3	1,295			

NOTE: L denotes linear component
Q denotes quadratic component
The variance ratio is considered significant at the 1 per cent. level and very significant at the 0·1 per cent. level.

"An Eye for Colour"

APPENDIX 1

Analysis of Variance

The technical changes take the form of a factorial experiment and a detailed statistical analysis was made for the plaques provided by manufacturer A. There are six factors entering the experiment which will be denoted as follows: "observers", "coats", "lights", "oxide", "colours" and "firing". Each factor has a certain number of "levels" since there were 8 observers, 2 coats (*i.e.*, a single cover coat and a double cover coat), 3 lights (*i.e.*, daylight, tungsten, and fluorescent), 3 oxides (*i.e.*, normal and ± 20 per cent. by weight), 3 colours (*i.e.*, normal, plus yellow, and plus red), and 3 firings (*i.e.*, normal, low, and high temperatures).

An analysis of variance [12] was carried out, but not to completion, since only the effect of interactions likely to be of interest or of significance were studied. The results are given in Table XIV.

It will be noticed that there is a significant main

effect for all the variables except coats and attention has been drawn to these in the paper. Some of the interactions have been referred to previously as compensations.

A similar analysis was carried out to find the effect of addition of grey oxide, and while no significant main effect was apparent this addition of grey oxide did give rise to significant interactions.

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Bright Nickel Plating

stress and high ductility. In addition, it should be well levelled and bright over a wide range of current density.

In order to get good adhesion, it is always advisable, before plating with bright nickel, to give a preliminary electrolytic polish in a suitable bath which can be a hot alkaline solution with a metal base of steel or alloys of copper and zinc. The cycle advised with a metal base of mild steel consists[53] of degreasing in the liquid-vapour phase with trichlor-ethylene, cathodic polishing in hot alkaline solution, anodic polishing in a similar solution, immersion in sulphuric acid (10 per cent. by volume) or, still better, in hydrochloric acid (15 per cent. by volume).

It is apparent that many of the problems relating to true bright nickel plating are still unsolved, and only continuing research and patient laboratory work will transform the process from a "fashionable" one to a truly scientific and fully understood aid to the finishing industry.

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FINISHING NEWS REVIEW

Paint Company Holds Jubilee Dinner

International Paints Celebrate 75th Year

TO MARK the 75th anniversary of the formation of International Paints (Holdings) Ltd., a dinner was held recently at the Savoy Hotel, London. Among those present were Sir Sigismund David Waley, K.C.M.G., C.B., M.C. (Director, International Paints (Holdings) Ltd.), Mr. J. W. Weber, Jnr. (President, International Paint Company Inc., New York), and Mr. Cyril Neroutsos, D.S.O. (Vice-president and Managing Director, International Paints (Canada) Ltd.).

In proposing the toast of the parent company, Mr. C. R. Petrie (Chairman and Managing Director) outlined the history of this world-wide organization. It started in 1881, when three men met in a small yard in Newcastle-upon-Tyne and started to mix and make anti-corrosive and anti-fouling compositions in wooden casks; they were Max and Albert Holzapfel and Mr. Petrie's father. The firm of M. Holzapfel and Co. was formed in November of that year and in 1883 the separate firm of Holzapfel, Petrie and Co. was created to market products in certain parts of the U.K.

In 1890 a new private company was formed under the name of Holzapfel Compositions Co. Ltd., and continued to trade under this name until 1908, when it was converted into a public limited liability company under the style of Holzapfel Ltd., with an issued capital of £450,000. In 1918 the name was changed to The International Paint and Compositions Co. Ltd., and again, in 1948, to International Paints Ltd. In 1951 it was again changed to International Paints (Holdings) Ltd., becoming purely an investment company, holding the shares of all subsidiary and associated companies, the paint trading activities being transferred to two new companies, International Paints Ltd., and International Paints Exports Ltd.

Not long after the first use of the company's well-known brands, the introduction of machinery made it possible to mix ingredients in iron tanks which were erected in a warehouse at Gateshead-on-Tyne. These modest premises were soon outgrown and a move made to larger buildings at South Shore, Gateshead, but within a few years the business had grown to such an extent, that a larger factory was needed and the works at Felling-on-Tyne were built and opened in 1904; they then covered 75,000 sq. feet on a site of 15 acres. Today they cover more than 200,000 sq. feet and the property covers 40 acres.

Since the end of the last war, great expansion and modernisation has taken place. A new production building was erected and a new varnish plant, the largest and most modern of its kind in the country, was built. A plant for making synthetic resins was constructed with a block of new offices, canteens and new laboratories.

In the early days, production was confined to ship's bottom compositions, but it was not long before the manufacture of general marine paints was begun. Today, in addition, the company makes every kind of industrial and decorative paints and surface coatings, as well as its own copper and mercury compounds, its own synthetic resins and satisfied its own demands for steel drums.

OIL AND COLOUR CHEMISTS' EXHIBITION

The London Section Exhibition Committee has now allocated the stands for the 1957 Ninth Technical Exhibition, which will take place from March 12-14, 1957, at the Royal Horticultural Society's New Hall, Greycoat and Elverton Streets, London, S.W.1. Space has been allotted to 88 companies and research associations. As before, the theme of the exhibition will be the presentation of technical advances in those industries supplying the paint, varnish printing ink, linoleum and other allied industries. The technical advances may relate to new products, new knowledge relating to existing products and their uses, or, in suitable cases, existing knowledge which is not generally available in the consuming industries. There will be no charge for admission nor for the descriptive brochures regarding the exhibits. An exhibition luncheon will take place at the Criterion Restaurant, Piccadilly, London, W.1, on March 12. The hours of opening of the exhibition will be: March 12, 3 p.m. to 7.30 p.m.; March 13, 10 a.m. to 7.30 p.m.; March 14, 10 a.m. to 7.30 p.m. Further information can be obtained from the General Secretary, Mr. R. H. Hamblin, M.A., Oil and Colour Chemists' Association, Memorial Hall, Farringdon Street, London, E.C.4. (Telephone: CENtral 2120.)

U.S. PLATING SUPPLIER SETS UP U.K. SUBSIDIARY

Harshaw Nickel Process Now Marketed Direct

The range of nickel plating processes supplied by the Harshaw Chemical Co. of Cleveland, Ohio, under the trade names of Perflow, Perglow, Nubrite and Nibrite, have been available for some years in this country through the agency of M. L. Alkan Ltd., Greenford, Middlesex. The American company has now set up Harshaw Chemicals Ltd. as a wholly-owned subsidiary in this country to manufacture and supply these processes in the U.K. The new company has premises in Eleanor Cross Road, Waltham Cross, Herts., where facilities include an electroplating service laboratory to provide analytical testing and advisory technical service to customers.

The general manager of the new company is Mr. A. C. Benning, who has a background of many years activity in production, technical service, and sales with the parent company. Assistant general manager is Mr. S. E. Pross.

The sales activities of the new company will not extend to the continent, where the Harshaw processes will continue to be marketed through the agency of L. van der Hoorn Chemisch - Technische Industrie, N.V., Utrecht, Holland.

COMPANY NOTES AND NEWS

The Battelle Institute Ltd., have moved to 24 Ryder Street, St. James's, London, S.W.1. Telephone: TRAfalgar 1621.

*   *   *

To develop their sales in France, a new associate company has been formed by **Johnson, Matthey and Co. Ltd.** The new company has taken over the merchanting business of Mons. P. Motton, agents for Johnson, Matthey products for the ceramic industry since 1917, and has also absorbed the business of Maurice Carriére et Cie, who have acted for the bullion department of Johnson, Matthey in France. Heading the new company is Mr. Basil McKenzie, assisted by Mons. Maurice Carriére. The other directors are Mons. P. Motton, Mr. W. G. Frank and Mr. P. G. Smyrk. The address is 76 Boulevard Haussmann.

*   *   *

It has been announced that the **Hepburn Conveyor Co. Ltd.,** Rosa Works, Wakefield, have obtained sole manufacturing rights in Great Britain of the shot-blasting and dust-control equipment of the Pangborn Corporation of Hagerstown, Maryland, U.S.A., and the selling rights for Great Britain, the sterling area and non-exclusive rights for many other countries including Germany and India. The company hope to be in production on the 6-ft. Rotoblast table room model and the 6-cu. ft. Blastmaster before the end of this year and to have prototypes ready by next spring.

*   *   *

The Birmingham office of **Matthews and Yates Ltd.,** fan and fan-equipment manufacturers, has been transferred to larger premises at County Chambers, Corporation Street, Birmingham 2. Telephone: Central 1089.

*   *   *

A sales and service organization has been set up by **Ipco Instruments** to cover the products manufactured by the companies in the Group. Technical information and service can now be obtained from local area managers and orders for the wide range of industrial instruments manu-

TECHNICAL AND INDUSTRIAL APPOINTMENTS

After 37 years as chief chemist of **W. Canning and Co. Ltd.,** Great Hampton Street, Birmingham 18, Mr. Ernest J. Dobbs has retired from the company and from the Board of which he has been a member since 1930. Mr. Dobbs, who joined the company at the beginning of 1919, has been responsible for the development of the company's research department and service laboratories, and his name is particularly associated with the development in this country of the bright chromium plating process. A member of many technical societies, Mr. Dobbs was a founder member of the Institute of Metal Finishing and served for several years on its Council.

*   *   *

In order to resume his private practice as technical consultant, Mr. Harold Rose, B.Sc., F.R.I.C., A.M.I.Chem.E., has relinquished his positions as technical adviser and director of Expandite Ltd.
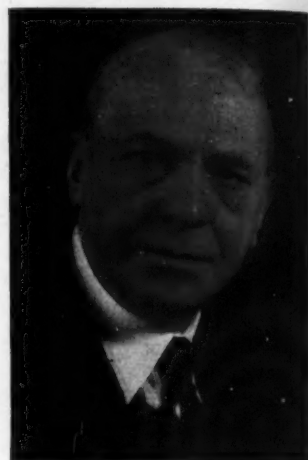
*   *   *

Relinquishing his position as chemist with Smiths Clocks and Watches Ltd., Mr. A. E. Kershaw has joined **Electro-Chemical Engineering Co. Ltd.,** as a technical sales representative, operating in the Midlands and South Wales.

*   *   *

A number of appointments have been announced by the **Incandescent Heat Co. Ltd.** Mr. J. A. Swain has relinquished the post of sales manager on his appointment as chief engineer of the Equiverse Sales Division, which has been specially created to market furnaces incorporating the Equiverse system of scale-free heating.

Mr. E. R. Dobbs

Mr. H. C. Newman, formerly manager of the Group Export Division, takes over management of the general sales division. Mr. G. C. A. Smith has been appointed manager of the Export Division of the Group.

*   *   *

Following the resignation of Mr. G. Wellesley, Mr. A. Kennedy has been appointed chairman of **Ault and Wiborg Ltd.** Other appointments include Mr. Alexander Crawford as managing director, Mr. K. B. Parrack, assistant managing director, and Mr. E. R. Bellfield as director.

factured by the companies in the Group will be dealt with by the new organization.

*   *   *

An agreement has been concluded between **Wolf Electric Tools Ltd.,** Hanger Lane, London, W.5 and Rallis' (India) Ltd., of Bombay, for the assembly and progressive manufacture in India of Wolf electric tools. Close collaboration between the contracting firms is planned to ensure the maintenance of Wolf standards of quality.

*   *   *

Work has been started on a new building to add a further 15,000 sq. ft. to the area devoted to the manufacture of buffing equipment and compounds by the **Schaffner Manufacturing Co. Inc.,** Pittsburgh, Pa. This constitutes the third addition to their plant space by the company in the past eighteen months.

INCREASED TITANIA PRODUCTION

It has been announced by British Titan Products Co. Ltd. that it is planned to extend still further the production facilities for titanium dioxide at Grimsby at a cost of more than £2 million. These extensions, which are due to be completed during 1958, are additional to the present extension programme due for completion early next year and will ultimately raise the production at Grimsby to 70,000 long tons a year, which is approximately seven times the initial output of the plant when it started up in 1949.

Production at the company's Billingham works continues at full output and the new production is required to meet the growing home demand for titanium pigments and to enable the company to develop its export trade.

PROCESS HEATING IN AN ELECTROPLATING PLANT

Steam-raising Practice at the Works of Norman Hay Ltd.

MANY electroplating and ancillary processes require the provision of means of heating to the process plant, and at the present time by far the greatest amount of such process heat for metal finishing is provided by steam. Hence, the provision of an efficient steam supply is an important factor when planning an electroplating lay-out. The large volume of solution which requires to be brought up to working temperature after weekend or other shut downs, requires a considerable heating time and it is therefore desirable where possible, to avoid adding to this the additional period for the boiler itself to commence steaming.

A recent example of the trend towards the use of modern high efficiency boiler plant in the plating industry has been the installation at the plating works of Norman Hay Ltd., Harmondsworth, Middlesex, of an oil-fired packaged automatic boiler, the Powermaster, manufactured by G. W. B. Furnaces Ltd., Dudley.

As jobbing platers, Norman Hay Ltd., carry out a very wide range of work, having facilities for deposition of most of the usual metals and for hard anodizing. Steam for the pretreatment and process lines was previously supplied by a mixed collection of units comprising two 350 lb. per hr. and two 250 lb. per hr. gas-fired boilers, together with a coke boiler giving approximately 625 lb. per hr. and a vertical oil conversion boiler, supplying around 800 lb. per hr. However, the increasing scope of the business made necessary the provision of further supplies of steam, with the result that the new model 100 Powermaster was installed, having a maximum nominal capacity of 3,400 lb. per hr.

In addition to coming up to steam rapidly, another useful feature of this type of boiler is that it may be placed in close proximity to the process line, reducing to a minimum the lengths of piping for steam supply and for condensate return. Furthermore, the automatic operation reduces the amount of supervisory labour. From Fig. 1 it can be seen that it was possible to instal the new boiler at the Norman Hay works in a small corner of the plating shop itself, the actual floor space required being only 12 by 7 ft.

In addition to process heating, the boiler is used for space heating in the buffing and finishing shop by means of overhead radiators and fans. For space heating purposes, the normal working pressure of the Powermaster boiler of 65 lb. per sq. in. is reduced to 20 lb. per sq. in.

The fuel used for this particular installation is medium oil of 200 secs. Redwood No. 1 viscosity, and the average consumption is around 12 gallons per hour. Before the installation of the new boiler, it was considered that the factory as a whole was under-boilered; the new unit is working on approximately one-half load. The only shutdown occurs over the weekend, when the boiler is switched off on Saturday midday while it is started up usually around Sunday midnight. Otherwise the boiler is working 24 hours per day.

I.C.I. "Alfloc" water treatment is carried out and it is found that with the type of water supply available, it is sufficient for it to be blown down four times per 24-hour day.

The maximum practicable size for a completely packaged boiler is reckoned to be that with an output of between 17,000 and 18,000 lb. of steam per hour with the equivalent B.T.U. rating of 17,000,000 B.T.U.'s per hour. Should greater outputs than this be required it is general practice to install several boilers adding up to the quantity of steam required. This is often extremely advantageous since one unit can then be looked upon as a stand-by boiler. This type of boiler can also be used for firing on gas, but this application is rather restricted in scope in this country owing to the relatively high running costs. It will be apparent that the packaged boiler represents the modern trend in automatic equipment, and indeed offers considerable advantages, both economic and mechanical over the more conventional type of boiler.

We are indebted to Norman Hay Ltd. and G.W.B. Furnaces Ltd., for the information and photographs contained in this description.

Fig. 1.—General view of new boiler manufactured by G.W.B. Furnaces Ltd.

Meetings of the Month

NOVEMBER 19

Metal Finishing Association.
Dinner Dance. Pavilion Suite,
Warwickshire County Cricket Ground.
7 p.m. till midnight.

**Institute of Metal Finishing
(London Branch).** Joint meeting
with S.A.S.M.U.T.A. "Some Aspects
of Production of Sheet-metal Components in Relation to Their Finishing
Techniques", by D. H. Lloyd,
F.R.I.C., F.I.M., at the Borough
Polytechnic, Borough Road, London,
S.E.1, at 6.15 p.m.

NOVEMBER 20

Sheffield Metallurgical Association. "Some Aspects of Ceramics in
Nuclear Energy", by Dr. P. Murray,
F.I.Ceram., at the B.I.S.R.A. Laboratories, Hoyle Street, Sheffield 3, at
7 p.m.

NOVEMBER 29

**Institute of Vitreous Enamellers
(Midland Section).** "The Care and
Maintenance of Vitreous Enamel
Plant", by J. H. Mayall, at the
Birmingham Exchange and Engineering Centre, Stephenson Place,
Birmingham 2.

NOVEMBER 30

**Institute of Metal Finishing
(Sheffield and N.E. Branch).** Open
Evening Discussion. Grand Hotel,
Fitzwilliam Room, Sheffield, 7 p.m.

DECEMBER 4 .

**Institute of Metal Finishing.
(Midland Branch).** Debate. James
Watt Memorial Institute, Great
Charles Street, Birmingham 3, 6.30
p.m.

DECEMBER 6

**Institute of Metal Finishing
(North-West Branch).** Film Show.
Engineers' Club, Albert Square,
Manchester, 7.30 p.m.

**Society of Chemical Industry
(Corrosion Group).** "Stress Corrosion", by K. R. Wilson, University
Chemical Department, Woodland
Road, Bristol, 6.30 p.m.

DECEMBER 7

**Institute of Metal Finishing
(London Branch).** Annual dinner
and dance at the Waldorf Hotel,
Aldwych, London, W.C.2.

TRADE and TECHNICAL PUBLICATIONS

"Pitakote": A leaflet has been
produced by Allweather Paints Ltd.,
36 Great Queen Street, London,
W.C.2, which describes their new
product Pitakote, an "Epikote"-based
paint. It is claimed to provide outstanding acid, alkali, solvent, fatty
acid, and abrasion resistance; gloss
and adhesion; flexibility and hardness;
and ease of application.

Information is given on the characteristics of the fully-cured Pitakote
paint coating including its weathering
properties, chemical resistance, heat
and cold-temperature resistance.

In the section dealing with "Instructions For Use" it states that Pitakote
is supplied as a two-pot system. There
is also information on thinners and
brush-cleaning liquid; care of brushes
and spray equipment; covering
capacity; surface preparation; curing
and coating after application; and
recommended painting systems,
covering bare iron and steel, aluminium, copper, concrete and wood.

Thickness Gauge: The Elcometer
thickness gauge for non-destructive
testing all kinds of films is described
in a brochure published by the East
Lancashire Chemical Co. Ltd., Fairfield, Manchester.

It states that the Elcometer quickly
and accurately gauges the thickness of
all non-magnetic coatings on iron and
steel bales. In addition, it will
measure the thickness of any nonmagnetic material if this is first laid
on a ferrous surface. The thickness is
read directly off the scale irrespective
of the type of coating being measured.

The Elcometer incorporates a strong
and durable permanent magnet. Magnetic flux across an air gap in the
instrument varies according to the
proximity of a ferrous surface to the
two contact spheres at the base of the
meter. An armature in this air gap, to
which a pointer is attached, is
influenced by the extent of this flux.
The pointer thus indicates on a scale
the thickness of any non-magnetic
material interposed between the
ferrous surface and the metal contacts.

Vitreosil Jubilee: A book has been
published by the Thermal Syndicate
Ltd., Wallsend, Northumberland, to
celebrate their golden jubilee.

It covers the history of the company
from their first experiments with fused
silica to the present day uses which
include alumina bricks and crucibles
for high temperature furnaces; stabilized zirconia crucibles and tubes for
use up to 2,400° C; fused silica
cooling coils; rings for industrial
electric rectifiers; insulators for
electrostatic dust and mist precipitators; cooling and absorption
plant for acid manufacture; and
Vitreosil immersion heaters, which
are employed today for heating
solution tanks in the electroplating
and associated industries.

The development of silica-covered
heating elements dates back to 1914
and their use in acid electroplating
and pickling baths from 1930.

Nickel Sulphamate Plating: In
this data sheet published by Albright
and Wilson Ltd., 49 Park Lane,
London, W.1, it states that the
advantages of nickel sulphamate baths
are that they will produce deposits in
which the in:ernal stress is low.

In addition, both internal stress and
hardness may be controlled from
tensile to compressive by the use of
organic addition agents. The company
claim that the control of these properties will produce distortion-free
deposits which do not lower the fatigue
strength of the base metal.

Information is given on applications; suggested composition of plating bath; type of deposits; operating
details and equipment.

DECEMBER 10

**Institute of Metal Finishing
(Organic Finishing Group).** "Legal
Liability of the Metal Finisher", by
A. A. B. Harvey, M.Sc., A.R.I.C.,
Barrister-at-Law, at the Birmingham
Exchange and Engineering Centre,
Stephenson Place, Birmingham 2, at
6.30 p.m.

DECEMBER 12

**Society of Chemical Industry
(Corrosion Group).** "Corrosion in
the Tropics", by H. R. Ambler,
14 Belgrave Square, London, S.W.1,
6.30 p.m.

DECEMBER 14

Oil and Colour Chemists' Association (Scottish Section). Annual
dinner dance.

**Institute of Metal Finishing
(Sheffield and N.E. Branch).**
"Anodic Oxidation and Dyeing of
Aluminium", by V. F. Henley, B.Sc.,
F.R.I.C., F.I.M., Fitzwilliam Room,
Grand Hotel, Sheffield, 7 p.m.

DECEMBER 15

Oil and Colour Chemists' Association (Scottish Junior Subsection). "Thixotropic Alkyds", by
Mr. North, B.Sc., at More's Hotel,
India Street, Glasgow, at 10 a.m.

DECEMBER 18

Metal Finishing Association.
Luncheon Meeting. Open Discussion.
Farcroft Hotel, Rookery Road,
Handsworth, Birmingham 21.

HESSIAN TO STOP CORROSION

JUTE hessian treated to protect bright-steel parts against corrosion and rusting is now in commercial production, following research work undertaken in the laboratories of the British Jute Trade Research Association.

The impregnated hessian, used as a wrapping for bright-steel strips and bars, is claimed to give full protection under all humid and acidic atmospheric conditions encountered in transit and storage. It is being supplied in varying widths and on rolls with cardboard centres for reeling off quickly in the wrapping operation. For use with high-speed wrapping machines, it can be supplied with a dustproof treatment.

An important feature is that only single wrapping is necessary for adequate protection of the steel even under extreme conditions.

The anti-corrosive treatment is also effective where jute bagging is employed for carrying bright-steel products.

SIGNIFICANT USE OF ENAMELLED PANELS

One of the most novel structures ever erected in Germany is now rising from the Rhine embankment in Dusseldorf.

Vitreous-enamel curtain walls, although becoming commonplace in the U.S.A., are being used for the first time in Germany to clad the twenty-four storey Mannesmann administration building. In accordance with the tradition of the company, the colours selected are blue and white.

The framework consists of welded steel tubes and the enamel panels have been supplied by the Bettinger Enamel Corporation, Waltham, Mass., U.S.A. They comprise a facing panel of 16-g. iron backed by 2-in. of paper honeycomb and vermiculite cement, with an inner face of steel sheet, either galvanized or vitreous enamelled. The panels are enamelled and assembled at the American works and are shipped to Germany ready for direct incorporation on the structure. The building is scheduled to be completed next year.

FINISHING NEWS REVIEW
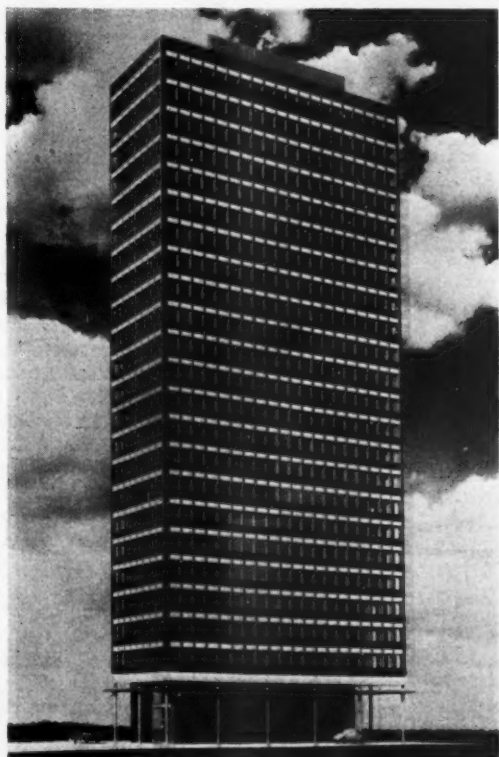
TWO IMPORTANT MEETINGS
Dates announced by I.M.F.

THE dates of two important meetings have been announced by the Institute of Metal Finishing. These are the Annual General Meeting, which will be held at the Northampton Polytechnic, St. John Street, London, E.C.1, on Monday, December 17, 1956, and the Annual Spring Conference.

The 1957 Conference technical sub-committee of the Institute, has already invited authors to submit their papers as soon as possible. Papers should be sent to the chairman of the sub-committee, Professor J. W. Cuthbertson, 28 Beeston Fields Drive, Beeston, Nottingham; the closing date for papers is December 15.

The Annual Spring Conference will be held at the Grand Hotel, Brighton, from Tuesday, April 9 to Saturday, April 13, 1957.

Day School to Discuss Degreasing

THE Metallurgical Engineering Committee of the Institute of Metals is holding an all-day informal discussion on "Degreasing" in the University, Edgbaston, Birmingham, on Wednesday, February 27, 1957. The meeting will be open to members and non-members and it is hoped that there will be a large attendance. Lunch will be arranged in the University refectory for those attending the meeting, provided they book lunch not less than seven days in advance. Members and non-members who wish to attend, should notify the Secretary of the Institute of Metals, 17 Belgrave Square, London, S.W.1, as early as possible.

OIL AND COLOUR CHEMISTS' ASSOCIATION

Once again the Ladies' Night will be held in the Grand Hall of the Criterion Restaurant, Piccadilly, London, W.1, on Friday, November 30. Application forms for tickets (price £1 13s.) may be obtained from Mr. H. C. Worsdall, 6 Cold Arbor Road, Sevenoaks, Kent.

Stoving by Convection and Radiation

(Continued from page 417)

motors, and the like. To find out whether the drying schedule in actual operations is the best is worth some effort.

Where the plant personnel cannot carry out an exhaustive test of this nature, this can be performed for a comparatively small outlay of money by specialists, either individuals or such organizations as the National Industrial Fuel Efficiency Service. The first factor to be known is "time". Every drying plant has a part which moves only when productive work is done. An operation or event-recorder, as manufactured by several instrument makers, will disclose operative and idle times (Fig. 7). Measurement of hot-air temperature by a recording thermometer is the next permanent measurement. During an efficiency test, humidity of exhaust air and air volume has to be measured, and conveyor speed should also be registered.

Fan speed, air dampers and generation of heat should all be adjusted to produce the desired effect in the shortest possible time. Sometimes a less efficient convection dryer can be made more efficient by introducing re-circulation of part of the exhaust air. Minimum possible exhaust air temperature with maximum saturation of outgoing air with humidity should be the target. It seems best to show the advantages of securing the lowest possible exhaust air temperature during an efficiency test by considering possible steam and fuel savings.

For example, a hot-air dryer normally discharges 14,000 lb. of air per hour at a temperature of 166° F, at a relative humidity of 18 per cent. The amount of heat saved by reducing exhaust air temperature to, say, 146° F can be calculated as follows: Heat saved during heating up the air= Weight of air × specific heat × temperature difference. This is $14,000 \times 0\cdot25 \times (166-146) = 70,000$ B.Th.U. per hour. Neglecting the savings derived from consideration of having also to heat up the water content of air, about 80 lb. of steam per hour savings can be expected. Reducing the air outlet temperature by 20° F, about 7 per cent. saving in steam consumption can thus be achieved, whereby the relative exhaust air humidity is allowed to rise to 28. From this example it can be seen that reconstruction of older existing dryers, based on operational test results, and using air recirculation not only improves the drying process as such, but also saves heat and fuel.

In general a useful analysis of test results carried out by a drying expert in close co-operation with the works engineer will disclose weak spots in drying operation.

In conclusion the author wishes to thank the manufacturers of drying plant for their co-operation in producing this series of articles. Special appreciation is due to paint manufacturing firms who have gone to great trouble to place test results and opinions at his disposal, particular thanks being due to Pinchin, Johnson and Co. Ltd., London, S.W.1, Cellon Ltd., Kingston-on-Thames, I.C.I. Ltd. (Paints Div.), Slough, Bucks, and Ault and Wiborg Ltd., London, S.W.18. Data and reference material have also been supplied by the Gas Council, London, S.W.1.

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Abrasion Resistance of Vitreous Enamel

(Continued from page 410)

of stainless-steel balls ($\frac{5}{32}$ in. diam.), and 20 ml. of water is poured into an accessory hole in the top of the retaining ring. The apparatus is then set to oscillate for the required time. The effectiveness of the abrasive is increased by the motion of the steel balls on the moving specimens.

Two test methods have been devised: one for determining surface abrasion resistance and the other for sub-surface abrasion resistance. The surface abrasion test is used when appearance is the main consideration, but the sub-surface test method is followed when protection of the underlying metal is the more important. In the first method, Pennsylvania glass sand, between 70 and 100 mesh, is used in the abrasive charge, and the test is run for five minutes. The specular gloss is measured before and after, and the percentage retained gloss at 45 degrees is the surface abrasion index.

For determining sub-surface abrasion, a coarse fused-alumina grain is used for the abrasive grit, and the test is operated for 45 minutes. The slope of the portion of the abrasion-time/weight-loss curve between the 15- and 45-minute points is taken as the abrasion index. The specimen is weighed at the end of each three 15-minute abrasion periods; a fresh charge is inserted at the beginning of each.

Tests of several porcelain enamels in the abrasion tester at four co-operating laboratories have led to the conclusion that the two test methods give satisfactory reproducibility. Results of the experiments show that the indices of abrasion resistance assigned to the various enamels are in general agreement with service experience.

Latest Developments

in

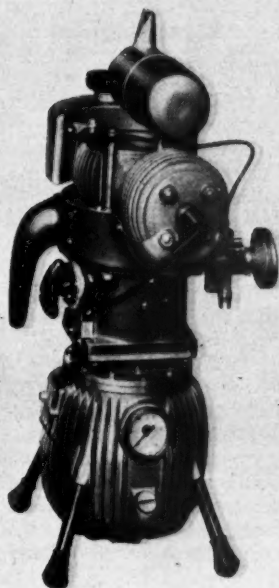# PLANT, PROCESSES AND EQUIPMENT

Fig. 1—Portable spray-painting unit

Portable Spray-painting Unit

A NEW ultra-light-weight petrol-engined portable spray-painting plant (Fig. 1) has been announced by Alfred Bullows and Sons Ltd., Long Street, Walsall.

This is comprised of the PR303 Hydrovane compressor powered by a 75-c.c. single-cylinder two-stroke petrol engine with one lever control for starting, running and stopping. The compressor unit and engine weigh only 46 lb. and can be carried by one hand with ease.

Easy starting is assured by the self-recoiling rope-type starter, and the low running speed of 2,200 r.p.m. gives long life and quiet operation.

The plant is complete with an L.800 spray gun with quart container, 30 ft. of air hose, and connectors, and will operate with a range of larger pressure containers, which are available as optional extras.

The electrically-driven version of this plant has been known for some years, and this new petrol-engined version is intended to meet a need for a self-contained spray-painting unit for use on undeveloped building sites, and other areas where no electric power supply is readily available.

Shaped Silver Anodes

ALTHOUGH silver was one of the earliest metals to be electro-deposited on a production scale, the basis electrolyte employed over a hundred years ago is still in every-day use. Until recently, operating difficulties associated with the progressive development of high anode-current density, leading to polarization, had never been satisfactorily overcome.

The Baker Platinum Division of Engelhard Industries Ltd. has introduced a new extruded silver-plating anode having a "dog-bone" cross-section which is designed to ensure uniform dissolution through the life of the anode. Extensive production tests have shown that anodes of this

Fig. 2--Contrast between new silver anode (right) and conventional anode (left) after use under identical conditions.
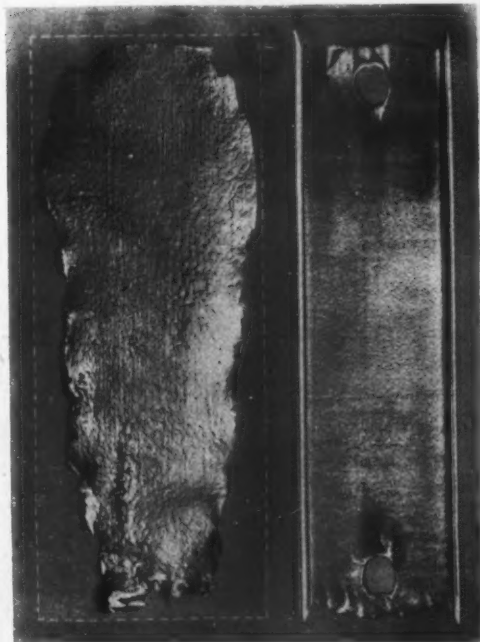
new type compare very favourably with conventional sheet anodes. It has been found that when both types of anode have been operated under similar conditions until only 15 per cent. of their original weight remains the loss of surface area is approximately three times greater for the conventional sheet anode than for the "dog-bone" anode. (*See* Fig. 2.)

An advantage of even dissolution is the elimination of anode "shedding" caused by the falling out of small particles at the thin edges developed on conventional anodes after comparatively short periods of use. The freedom from these "shed" particles by the use of the new anodes give smoother deposits free from roughness.

The anodes are produced under strict laboratory control, and uniformity of purity and grain-size is ensured by routine analysis and testing.

"Dog-bone" anodes are available 3 in. wide by approximately $\frac{1}{4}$ in. thick, and in any length to suit requirements. The anodes weigh approximately 4 oz. troy per linear in. and are drilled at each end to take supporting hooks up to $\frac{1}{4}$ in. diameter.

Cast Steel Shot

THE value of cast steel shot as an abrasive cleaning medium has for some time been appreciated in the U.S.A. and it is of interest to users of shot-blasting equipment in this country that Tilghman's Ltd., Broadheath, Altrincham, Cheshire, in conjunction with their associate company Bradley's (Darlaston) Ltd. are now producing cast steel shot on a commercial basis.

Wheelabrator steel shot is produced from high-quality electric-furnace steel, which is given a double heat treatment to produce a tempered martensite microstructure, resulting in a shot with a high degree of toughness, solidity, uniformity and operational efficiency.

The microstructure of shot is the primary factor in determining such major issues as cleaning speed,

shot life, and plant maintenance under subsequent operational conditions.

Comparative figures from a number of tests carried out by Tilghman's Ltd. in various types of Wheelabrator plants on a wide range of workpieces would indicate that Wheelabrator steel shot has an effective life approximately six to eight times that of chilled-iron shot.

The average shot consumption over three independent tests was:

Steel shot: 6·7 lb. per wheel hour.
Crushed chilled-iron shot: 43·1 lb. per wheel hour.
Average saving in cost per ton cleaned: 26·3 per cent.

The life of protective wearing plates, which came within the effective area of the shot-blast stream and of other machine parts, within an area subject to shot ricochet, was greatly increased, while blade wear was considerably reduced, when steel shot was employed. When using chilled-iron shot, deep grooves were scored in the blade face. Blades used with steel shot showed very little wear after 103 hours running. (*See* Fig. 3.)

The quality of finish obtained by cast steel shot is more matt in appearance than when using chilled-iron shot, and actual blast cleaning time is reduced by between 5 and 10 per cent.

While the original cost of Wheelabrator cast steel shot is higher than conventional chilled-and-heat-treated iron abrasives, the makers claim that when all factors are taken into consideration, a reduction of 15 to 25 per cent. in overall operating costs can be expected.

Recording of Flaw Detection Readings

A SIMPLE, quick and inexpensive method of recording the results of magnetic flaw detection has been developed by Industrial Tapes Ltd., 142-146 Old Street, London, E.C.1, working in close

Fig. 3—Comparison between blades shot-blasted with cast steel shot and cast chilled-iron shot.

CAST STEEL SHOT   CRUSHED SHOT
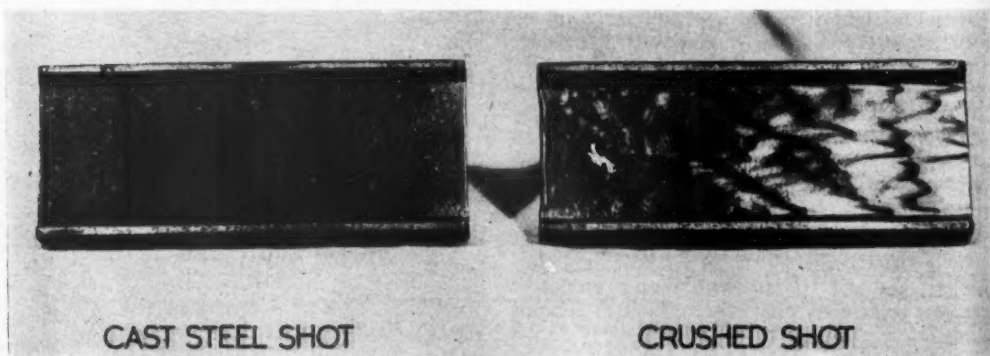
NOT TOO SMALL

For Hot Galvanizing

Through modern pre-occupation with the large and spectacular, we often forget the vital importance of the little things—the nails, washers, nuts and bolts which keep the parts together. These, not less than the main steel structures need hot galvanizing—the best way of ensuring long term protection at a reasonable cost. Few articles are too small to be treated. Up-to-date methods of centrifugal galvanizing allow small parts to be given a heavy and uniform coating of zinc. Threads as fine as those on a 5/16″ diameter bolt can be galvanized ready for use—with no subsequent cleaning required. Whatever the size of a part, large or small, it can usually be galvanized.

Hot Dip Galvanizers Association

Latest Developments (*Continued from page* 442) association with Radalloyd Ltd., of Leicester.

The method is used in conjunction with a normal flaw detector of the magnetic type. The part or weld under examination is covered with a variety of Speedfix tape specially developed for the process. This has a white surface, which is coated with special flaw-detection ink during the inspection.

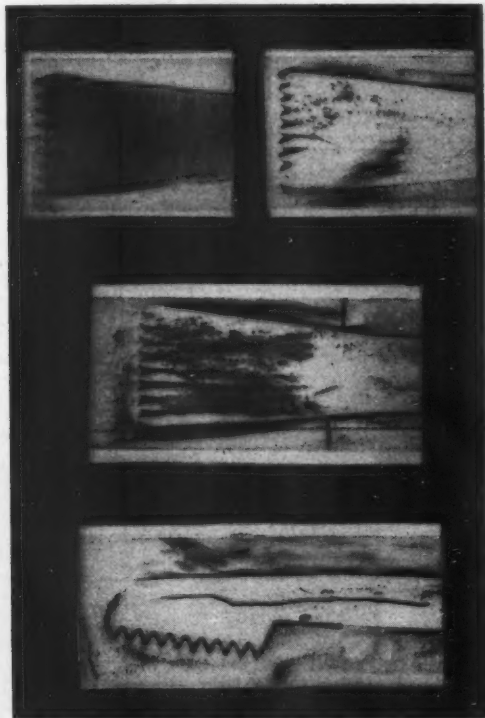The part is placed between the jaws of the flaw

Fig. 4—Typical flaw patterns fixed and recorded with flaw-detection tape.

detector in the normal way, the magnetic flux producing the flaw pattern. At this point, the picture of the flaw is covered with Speedfix Vinyl No. 12 transparent, which fixes the detection ink and provides a permanent picture of the flaw pattern (Fig. 4) which can be then detached, numbered or otherwise marked for retention, decision and action by the Inspection Department. The "fixed" picture is photographically clear and minute defects show more clearly than by ordinary inspection.

The method is simple, and can be used by normal inspection personnel without training or additional work.

Other tapes have been developed for non-destructive surface flaw detection on non-magnetic materials in conjunction with fluorescent penetrants, coloured penetrants, or colloidal graphite.

In the latter case the method is of great value where hairline cracks barely visible to the naked eye have to be detected. It is also ideal for recording the "craze pattern" which shows on chromium deposits when reverse etched to produce an oil-retaining surface.

### Fans for Fume Removal (Fig. 5)

A RE-DESIGNED and extension of range of P.V.C. fans has been announced by Turner and Brown Ltd., chemical plant engineers of Davenport Works, Bolton, in association with Matthews and Yates Ltd., fan engineers of Cyclone Works, Swinton, Manchester.

This combination of long experience of fan design with technical knowledge of P.V.C. fabrication has produced a range of P.V.C. fans under the trade name "Turbro-Cyclone".

"Turbro-Cyclone" fans are fabricated throughout from olive green "Cobex" rigid vinyl sheet, manufactured by BX Plastics Ltd., which is tough and light, dimensionally stable and non-inflammable. Such construction makes these fans suitable for all kinds of fume removal installations which handle chemical and corrosive fumes and moist gases, etc., at temperatures not exceeding 140° F.

The smallest of the fans, with direct-coupled motor, has been especially designed for fume cupboards, cabinets and small laboratories, while the other fans have larger outputs, and are available either direct coupled or with vee-rope drives. In all cases a totally enclosed motor wound for either single-or three-phase electrical supply is employed.

Fig. 5—Fume-removal fan.
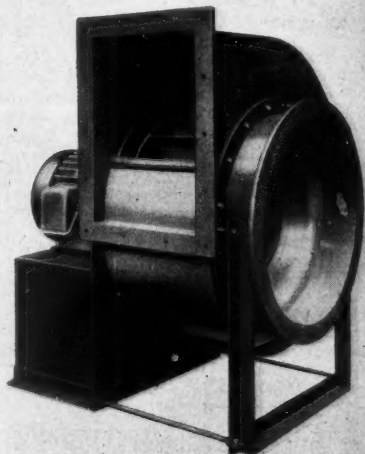
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